62-5010-E

Instruction Manual

MODEL 2480/2480R

BENCH/PORTABLE 4-1/2 DIGIT DIGITAL MULTIMETER

MP MASTER
MA28676

DATA PRECISION

62-5010-E

Instruction Manual

MODEL 2480/2480R

BENCH/PORTABLE 4-1/2 DIGIT DIGITAL MULTIMETER

DATA PRECISION

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CONTENTS

Chapter **Title**

1. INTRODUCTION

1.1 General, Scope of Manual
1.2 Operating Features
1.3 Specifications
  1.3.1 DC Volts
  1.3.2 Resistance
  1.3.3 DC Current
  1.3.4 AC Volts
  1.3.5 AC Current
  1.3.6 All Measuring Modes
1.4 Accessories

2. OPERATION

2.1 General
2.2 Unpacking and Repacking
2.3 Front Panel Controls and Indicators
2.4 Rear Panel Features
2.5 Operation
  2.5.1 General
  2.5.2 Signal Connections
  2.5.3 Selecting a Measuring Function
  2.5.4 Selecting Range
  2.5.5 Reading the Display
2.6 Application Notes
  2.6.1 General
  2.6.2 Avoiding Ground Loops, Making "Grounded" Measurements
  2.6.3 Making "Floating" Measurements
  2.6.4 Making High Resistance Measurements
  2.6.5 Making Very Low Voltage Measurements
2.7 Operator Servicing

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3. CALIBRATION

3.1 General
3.2 Calibrating Adjustments
3.3 Calibration Procedures

4. PRINCIPLES OF OPERATION

4.1 General
4.2 Overall Block Diagram and System Timing
    4.2.1 Input Signal Scaling
    4.2.2 Tri-Phasic A/D Conversion
    4.2.3 Digital Logic Programmer
    4.2.4 Decoder Driver and Display
    4.2.5 Reference Generator
    4.2.6 DC/DC Converter & Power Supply
4.3 Input Signal Conditioning Details
    4.3.1 Voltage Attenuator
    4.3.2 DCV Signal Conditioning
    4.3.3 ACV Signal Conditioning
    4.3.4 Current Shunt & Current Input Signal Conditioning
    4.3.5 Resistance Measurement Signal Conditioning
4.4 Tri-Phasic A/D Converter Details
4.5 Isopolar Referencing
4.6 Digital Logic Programmer & Master Oscillator
4.7 Display
4.8 DC/DC Converter & Power Supply

5. MAINTENANCE

5.1 General
5.2 Trouble-Shooting Flow Chart
5.3 Test Points
5.4 Field (Operator) Maintenance
5.5 Open-Meter Test Maintenance
    5.5.1 General
    5.5.2 Access to Meter Assembly in Case
5.6 Test Equipment
5.7 Power Supply Test

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5.8 Digital Logic Test
5.8.1 Time-Base Generation
5.8.2 Program Logic
5.8.3 Decoder/Driver Logic
5.9 A/D Converter & Signal Conditioners Test
5.9.1 Analog A/D
5.9.2 AC/DC Signal Conditioner
5.10 Post Trouble-Shooting & Repair

6. PARTS LISTS

Fold Out Reference Drawings

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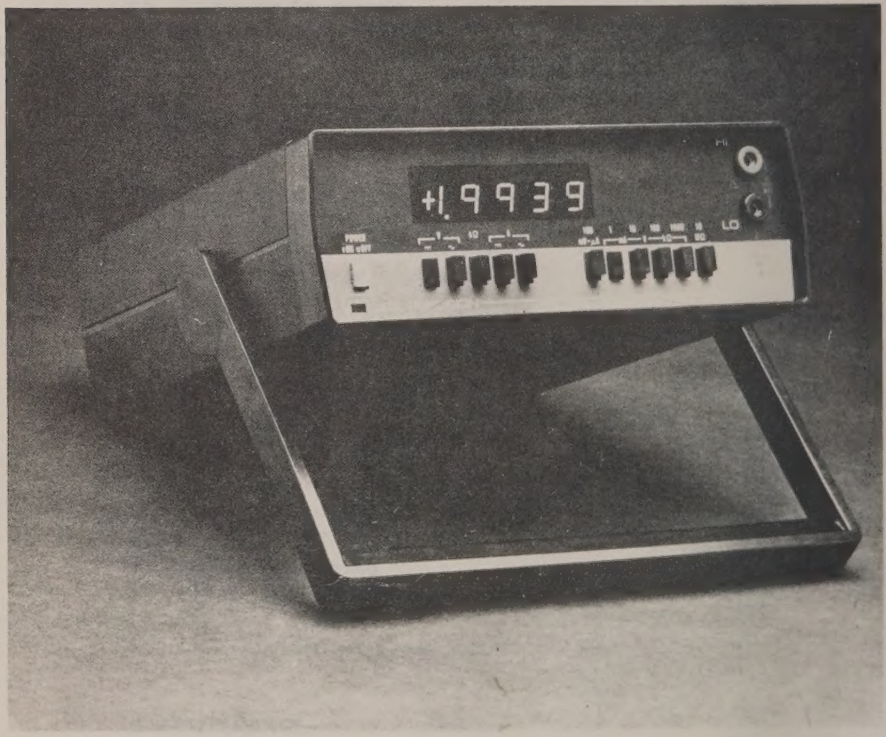

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Chapter 1
INTRODUCTION

1.1 GENERAL, SCOPE OF MANUAL

a. Data Precision Model 2480/2480R Digital Multimeter is a 4½ digit, laboratory quality, portable as well as bench-useful, multimeter, incorporating 25 Measuring Function/Range capabilities. These include: DCV, ACV, DCmA, ACmA, and KOhms. Resolutions of 10 microvolts, 0.1 ohms, and 10 nanoamperes are obtained at the lowest selectable full scale range, while voltages up to 1200VDC or 1400 peak AC and currents up to 2 amperes may be measured by Model 2480/2480R with 4½ digit resolution and specified accuracies. All values are direct reading with automatically positioned decimal point and polarity sign (for dc measurements only).

b. Model 2480 measures ac inputs with average sensing calibrated for RMS, while Model 2480R measures ac inputs with true RMS values. All other measuring functions are performed in the same manner in Model 2480 or Model 2480R.

c. Information in this manual is organized so that operators and system users may locate applicable data and instructions (through Chapter 3) without having to wade-through technical detail necessary for maintenance and repair. Information in Chapters 4 and 5 essentially support the technical requirements for maintenance, trouble-shooting, and repair activities.

d. The basic Model 2480/2480R is complete with integral battery charger, detachable line cord, and test probes. Optional battery pack assembly may be installed in the field at any time.

1.2 OPERATING FEATURES

Model 2480/2480R Digital Multimeter provides the user with a number of unusual performance features. Among these are:

(a) **Laboratory Bench or Field Portability:** obtained by a built-in battery charger and a field-installable battery. The battery is always being recharged when the line cord is connected to the ac source, even while the instrument is not in operation (OFF).

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(b) **Easy-to-Read Display:** obtained by using bright, large (0.43 inch-high), LED's behind a non-reflective optical filter.

(c) **Easy-to-Understand Display Measurements:** Engineering units for direct-reading values are engraved directly above function selector pushbuttons. Automatic positioning of decimal point removes need for any further interpretive reading of displayed value. Polarity signs are displayed for dc measurements. Blanking of digits for out-of-range signals prevents reading invalid displays.

(d) **Low-level Battery Monitoring:** Decimal point starts to blink when battery level drops to provide 10 or more minutes of operating power. 12-hour recharge cycle develops full charge for 6 hours of continuous operation. Blinking decimal point also indicates a very low ac line voltage when no battery is used.

1.3 SPECIFICATIONS (For 1 year, without recalibration)

1.3.1 DC VOLTS:

Nominal Range	Full Scale	Resolution
100mV	±199.99mV	10μV
1V	±1.9999V	100μV
10V	±19.999V	1mV
100V	±199.99V	10mV
1000V	±1200.0V	100mV

Input Impedance:
10MΩ, all ranges

Maximum Voltage:
±1200V, all ranges momentary, ±1000V continuous

Accuracy: (1 year, 18°C–28°C):
100mV Range ±(0.03% inp + 2d)
1, 10, 100, 1000V Ranges ±(0.03% inp + 1d)

Temperature Coefficient (all ranges):
±(0.003% inp + 0.001% Range)/°C

Common Mode Voltage:
500 VDC (or peak AC)

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Common Mode Rejection Ratio (with 1000 ohm source impedance unbalance):

>120dB at DC

>100dB at 50Hz and at 60Hz

Normal Mode Rejection Ratio:

60dB at 50Hz and at 60Hz

1.3.2 RESISTANCE:

Range	Full Scale	Resolution	Maximum Test Current
1kΩ	1.9999kΩ	100mΩ	1.8mA
10kΩ	19.999kΩ	1Ω	330μA
100kΩ	199.99kΩ	10Ω	35μA
1000kΩ	1999.9kΩ	100Ω	3.5μA
10MΩ	19.999MΩ	1000Ω	0.35μA

Accuracy (1 year, at 23°C ±5°C):

Range	Accuracy
1, 10, 100	±(0.05% inp +1d)
1000	±(0.1% inp +1d)
10MΩ	+(0.25% inp +1d)

Temperature Coefficient

Range	Coefficient
1, 10, 100	±(0.005% inp +0.001% range)/°C
1000	±(0.01% inp +0.001% range)/°C
10MΩ	±(0.02% inp +0.005% range)/°C

Measuring Configuration:

2-wire

Maximum Open Circuit Voltage:

3.5 volts

Maximum Fault Voltage:

500V RMS AC or DC

Settling Time (in seconds):

0.7 +(0.3) (Resistance in MΩ)

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1.3.3 DC CURRENT:

Range	Full Scale	Resolution
100μA*	±199.99μA	10nA
1mA*	±1.9999mA	0.1μA
10mA*	±19.999mA	1μA
100mA*	±199.99mA	10μA
1000mA*	±1999.9mA	100μA

*Maximum Current: Limited to 2A on all ranges. Fuse-protected when measuring current in circuits with open-circuit voltage of 250VDC or less.

Nominal Full Scale Voltage Across Shunts:
100mV

Accuracy (1 year, at 23°C ±5°):

Range	Accuracy
100μA, 1, 10	±(0.1% inp +1d)
100, 1000	±(0.2% inp +1d)

Temperature Coefficient

Range	Coefficient
100μA, 1, 10	±(0.01% inp +0.001% Range)/°C
100, 1000	±(0.02% inp +0.001% Range)/°C

1.3.4 AC VOLTS:

Range	Full Scale	Resolution
100mV	199.99mV	10μV
1V	1.9999V	100μV
10V	19.999V	1mV
100V	199.99V	10mV
1000 VAC*	1000.0V*	100mV

*See maximum input voltage limits below:

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Input Impedance:
10MΩ in parallel with 75pf or less.
Accuracy: (1 year at 23°C ±5°C):

Frequency		RMS Option**	Average Option
All ranges	20Hz	±(1% inp +50d)	±(1% inp +10d)
	50Hz to 500 Hz	±(0.4% inp +20d)	±(0.2% inp +2d)
	2kHz to 20kHz	±(1.0% inp +20d)	±(1% inp +5d)
1,10,100, 1000 ranges	50kHz		±(1% inp +10d)

*Interpolate between frequency points.

Temperature Coefficient (all ranges):

Frequency	RMS Option**	Average Option
20Hz to 500Hz	±(0.02% inp +0.02% Range)/°C	±(0.01% inp +0.002% Range)/°C
2kHz to 20kHz	±(0.1% inp +0.02% Range)/°C	±(0.1% inp +0.02%C Range)/°C
50kHz		±(0.1% inp +0.05% Range)/°C

*Interpolate between frequency points.
**Crest Factor: 5 up to nominal range, decreasing to 2.5 at full scale.

Maximum Input Voltage (Sinewave):
20Hz to 10kHz: 1000V RMS
Above 10kHz: Decreasing to 200V RMS at 50kHz

Settling Time:
2.5 seconds max. to ±0.1% of final reading for full-scale step input change.

1.3.5 AC CURRENT

Range	Full Scale	Resolution
100μA*	199.99μA	10nA
1mA*	1.9999mA	100nA
10mA*	19.999mA	1μA
100mA*	199.99mA	10μA
1000mA*	1999.9mA	100μA

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*Maximum Current: Limited to 2A on all ranges. Fuse-protected when measuring current in circuits with open-circuit voltage of 250VDC or less.

Nominal Full Scale Voltage Across Shunts:
100mV RMS

Accuracy: (1 year, at 23° ±5°C) (all Ranges):

Frequency*	RMS Option**	Average Option
20Hz	±(1.5% inp +50d)	±(1% inp +10d)
50Hz to 1kHz	±(0.75% inp +20d)	±(0.3% inp + 4d)
5kHz to 20kHz	±(1.5% inp +20d)	±(1.5% inp + 10d)

*Interpolate between stated frequencies.

Temperature Coefficients (All Ranges)

Frequency*	RMS Option**	Average Option
20Hz to 1kHz	±(0.03% inp +0.02% Range)/°C	±(0.03% inp + 0.01% Range)/°C
5kHz to 20kHz	±(0.1% inp +0.02% Range)/°C	±(0.1% inp + 0.01% Range)/°C

*Interpolate between stated frequencies.
**Crest Factor: 5 at nominal range, decreasing to 2.5 at full scale.

1.3.6 ALL MEASURING MODES:

Reading Rate:
2.5 readings/seconds

Polarity:
Automatic plus (+) or minus (−) displayed for all DC measurements.

Overload:
Indicated by blanking of all digits; decimal point and polarity (if appropriate) remain lighted.

Display:
0.43" LED's

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Battery Operation:

The optional battery module contains six (6) NiCd batteries, capable of providing up to six (6) hours of fully reliable operation between charges. Recharging of batteries requires approximately 12 to 16 hours.

Low Battery Indicator:

Decimal point blinks 2.5 times/sec. indicating approximately 10 minutes of in-spec operation remaining before recharging.

Power Consumption:

a. With optional battery pack charging — less than 3 watts.
b. Without battery installed — less than 2.5 watts.

Temperature Range:

Operating: −10°C to +55°C. (0°C to +40°C with optional NiCd battery pack installed)

Storage: −40°C to +80°C (−25°C to +50°C with optional NiCd battery pack installed)

Humidity: 0 to 80% RH max.: 0°C to +40°C
0 to 70% RH max.: 40°C to +55°C

Physical:

The Model 2480 measures 8½" wide by 2⅞" high by 8⅞" deep (21.6 × 7.3 × 22.5 cm). It weighs only 2.5 pounds net (1.1kg.) and 3.0 pounds (1.4kg) with battery. A combination carrying handle and tilt stand is provided.

Line (mains) Voltage (47-400Hz):

Model 2480/2480R: 105–125 VAC
Model 2480E/2480RE: 210–250 VAC
Model 2480J/2480RJ: 90–110 VAC

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1.4 ACCESSORIES (OPTIONS)

The following optional accessories are available to extend the Model 2480/2480R DMM performance; they may be obtained from Data Precision distributors.

Description	Data Precision Model No.
*Test Leads	T5
Rack Mount (L, R, or Dual)	RMD1
High Voltage Probe (to 40KV)	V41A
AC Current Probe (to 150 Amp.)	IP151
Deluxe Test Leads Kit	T7
Battery Pack	C48
*Line Cord	L45
AC Current Probe (Clamp-on, 10 to 1000 Amp)	IP1001
RF Probe	RF471
Retractile Hook for RF471	RFH1
Isolation Probe	RP100
Temperature Probe	TP151
Carrying Case	CC50

*Included as standard items at no additional charge.

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Chapter 2
OPERATION

NOTE:

Read this chapter carefully before attempting to use your Model 2480/2480R DMM. Retain these instructions. Observe all WARNINGS and CAUTIONS.

2.1 GENERAL

a. Chapter 2 contains detailed instructions for connecting and operating the Model 2480/2480R DMM, including safety precautions to prevent damage to personnel or equipment. In addition, the chapter contains some application notes designed to assist users to obtain valid measurements in harsh environments. Refer to the specifications in paragraph 1.3 to obtain the tolerance with which displayed measurements may be interpreted.

b. Safety Markings The front panel incorporates two standard operator warnings. The significance of each is:

Located between input terminals "HI" and "LO".

This advises the operator to refer to the instruction manual before using these terminals.

Located to the right of terminal "HI".

This warns the operator that there may be dangerously high voltage at this location, or that there is a voltage limitation to be considered when using this terminal.

The rear panel mounts a standard grounding lug, electrically connected to the "ground" terminal of the 3-wire line cord receptacle in the rear panel.

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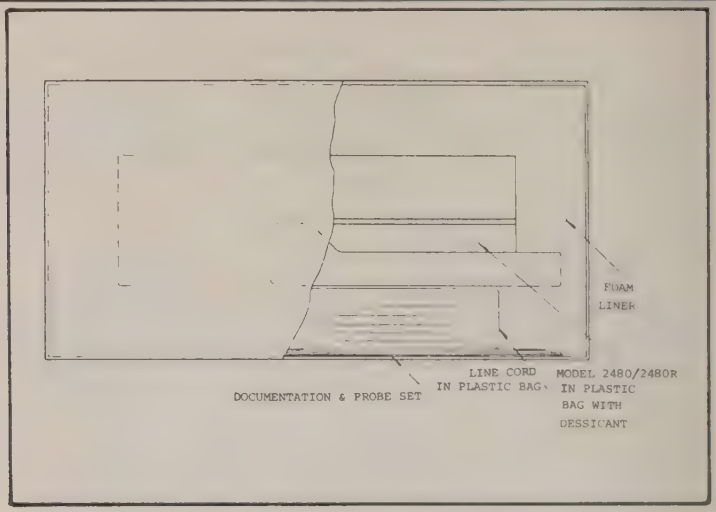

Figure 2-1 — Model 2480/2480R Packing Configuration

2.2 UNPACKING & REPACKING

a. Figure 2-1 identifies the components of the packaging configuration for Model 2480/2480R DMM. As shown in that illustration, the multimeter is placed in a waterproof plastic wrapper, securely fitted between molded-foam shock isolators, and placed with the documentation in its shipping carton. When unpacked, you should find:

(1) Model 2480/2480R DMM
(2) Line Cord
(3) Test Probe Assembly & Alligator Clips
(4) Certificate of Conformance
(5) Warranty Card
(6) Factory Test Data Sheet
(7) Spare 2A, 250V, 3AG Fuse, F301
(8) Spare 1/16A, 250V, 3AG Fuse, F300

b. Carefully examine these articles, noting especially the matching serial numbers of the instrument and the test data. Inspect the packing case and the instrument for any signs of damage during shipment and report immediately to the carrier. Fill out and return the warranty card to register your instrument and to establish your warrantied service interval.

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c. Accessories, such as spare leads or high voltage probes, may have been ordered. These will be shipped in their own containers. The battery assembly, if ordered with meter, will be installed prior to shipment.

d. Retain the packing material for reshipment.

e. When re-shipping Model 2480/2480R DMM, place the instrument in its protective carrying case, including test probes and line cord. Use foam liners and pack in original shipping carton, if available.

f. If the Model 2480/2480R DMM is to be kept stored without use for any appreciable time (6 months or more) and a battery assembly is installed, the battery should be recharged every 6 months.

2.3 FRONT PANEL CONTROLS & INDICATORS

Figure 2-2 and Table 2-1 identify and describe operating features at the front panel of the standard Model 2480/2480R Digital Multimeter.

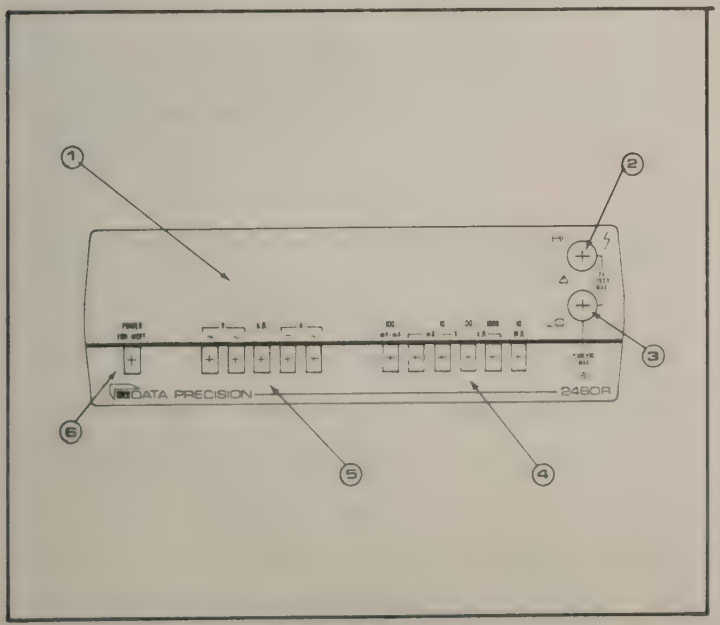

Figure 2-2 — Model 2480/2480R DMM Front Panel Features

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Table 2-1 (Figure 2-2)
FRONT PANEL OPERATING CONTROLS & INDICATORS

Fig. Item	Name	Functional Description
1	Display	0.43″ LEDs; 4 full decades; MSB1; automatic polarity (when appropriate); automatic range-selected decimal point; low battery blink; out-of-range blanking (except decimal point).
2	HI (J400)	Banana-plug receptacle for high input (with respect to LO). Polarity of dc measurements is that of HI input with respect to LO input connection.
3	LO (J401)	Banana-plug receptacle for low input (with respect to HI). See item 2.
4	Range Selectors (6)	Push switches, interlocked so that selection of any one automatically releases the prior selection. Five range scales selectable for each measuring function; nominal range scale value marked above each switch; see specifications for full scale range (including overrange.)
5	Measuring Function Selectors (5)	Push switches, interlocked so that selection of any one automatically releases prior selection. Functions (DCV, ACV, DCmA, ACmA, KΩ) are screened over appropriate switch push button.
6	POWER ON-OFF	Push-push switch. When active (IN position) connects power to meter circuitry. When optional battery is installed, ac line power when connected always charges battery, whether or not power is ON or OFF.

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2.4 REAR PANEL FEATURES

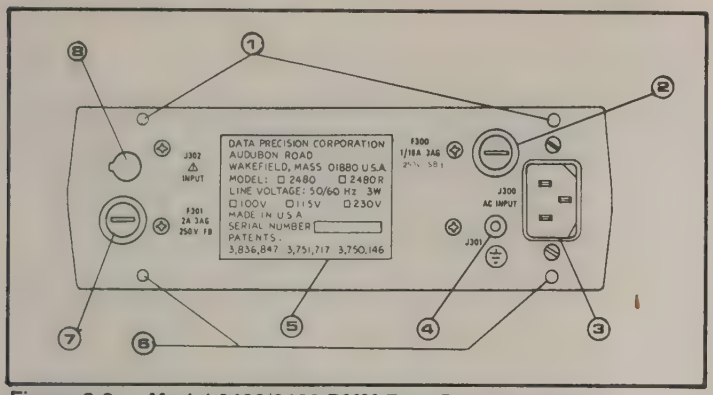

Figure 2-3 — Model 2480/2480 DMM Rear Panel Features

Table 2-2 (Figure 2-3)
REAR PANEL FEATURES

Fig. Item	Title	Functional Description
1	Fastening Screws (2)	2 screws fastening top cover to rear panel assembly.
2	F300	1/16 A line fuse
3	Line-cord receptacle (J300)	3-prong receptacle; center prong line ground, connected to transformer shield and rear panel ground terminal.
4	J301	Line ground terminal.
5	Label	Meter identification, Serial No. Power, etc.
6	Fastening Screws (2)	2 screws fastening bottom cover to rear panel assembly.
7	F301	2A series fuse for current overload protection.
8	J302	Optional Rear Input (Wired in Parallel with Front Panel)

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2.5 OPERATION

2.5.1 Powering

a. Model 2480/2480R Digital Multimeter is powered by 110VAC (Model 2480/2480R) or 230VAC (Model 2480E/2480RE) or 100VAC (Model 2480J/2480JE) as determined by the ordered configuration. (See rear panel label.) Connect the line cord to the rear connector (Figure 2-3, item 3) and to the power source. In addition, any Model 2480/2480R may be powered by an accessory battery assembly, C48, field-installable in guides within the case. When a battery assembly is installed, it is always being recharged when the ac power is connected.

b. Turn on power by operating the switch (Figure 2-2, item 6).

c. Voltage output of an installed battery assembly is monitored (when the power switch is turned ON) by standard internal circuitry, and a low-level battery output is indicated by a blinking decimal point in the display. A completely charged battery assembly will supply 6 hours of trouble-free performance, and 12 recharging hours will fully charge a completely discharged battery assembly. In absence of battery, blinking decimal point indicates an excessively low line voltage source.

d. The multimeter may exhibit certain battery performance below rated characteristics that are only temporary operational effects typical of battery usage patterns. Such below-specification performance can be corrected easily and in a minimum of time.

Memory. If the meter is used in a series of repeated partial charge and discharge cycles that use only a small portion of the available battery capacity, the battery will become conditioned to delivery only slightly more than normal end-of-discharge voltage capacity when called on to perform in an extended discharge cycle.

To correct this condition, subject the battery to a deep discharge, and then recharge to full capacity. This will erase the "memory" pattern.

Sustained Overcharge. If the meter is kept on "high voltage charge" for long periods of time without discharge interruptions, the battery may not deliver normal voltage at the end of the first sustained discharge operation thereafter.

To correct, proceed as for the memory effect described above: discharge the battery, then recharge to full capacity.

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WARNING

Inputs applied through rear-panel connector are paralleled to front panel plugs. Check for any rear inputs before making any front-panel connections. Remove any rear panel connections before using front-panel inputs, and vice-versa.

2.5.2 Signal Connections

a. A pair of test leads are furnished as standard accessories with each ordered Model 2480/2480R Digital Multimeter. A banana plug connector at one end mates with the Digital Multimeter front panel input connector, while the probe end of each lead may be configured for spade lug contact. Alligator clip adaptors are furnished at no additional charge with each standard test lead set.

b. When measuring with a Model 2480/2480R Digital Multimeter that is connected to ac power, it is important to minimize ground loops that may introduce noise into the input circuit. (See applications data, paragraph 2.6).

c. Input terminals (Figure 2-2, Items 2 and 3) are used as the front panel connector pair to measure voltages up to 1000 volts, currents up to 2 amperes and resistances up to 20 Megohms.
See WARNING at start of paragraph 2.5.2.

CAUTION

Before connecting the Model 2480/2480R DMM to the unit under test, be sure that the values would not exceed the limits indicated on the front panel.

d. Connect leads to Model 2480/2480R DMM and to the unit under test.

2.5.3 Selecting a Measuring Function

Select one of 8 measuring functions by operating the appropriate push button (Figure 2-2, Item 5). The push buttons are interlocked so that operating any one will release any other one.

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2.5.4 Selecting Range

a. Operate the pushbutton for a range scale expected to exceed the highest value expected. If an out-of-range indication appears in the display, choose the next higher range until an in-range value is displayed. If the first range selection results in a display of less than 190 counts, a greater resolution may be obtained by choosing the next lower range scale.

b. For ac or dc voltage, the highest range is 1000; the lowest is 100mV. For resistance measurements, the highest range is 10MΩ; the lowest is 1kΩ. For ac or dc currents, the highest range is 1000mA; the lowest is 100μA.

2.5.5 Reading the Display

a. The display is direct reading in the engineering units selected by the range scale (mV, V, μA, mA, kΩ and MΩ) with automatic positioning of the decimal point. Polarity for dc measurements is indicated to the left of the most significant digit; no sign is indicated for any ac or ohms measurements. If the input signal exceeds the selected range scale, the digits will be blanked, the decimal point and the polarity sign (if appropriate) will remain lighted. A blinking decimal point indicates a low battery, or, in absence of battery, a low line voltage. See paragraph 2.5.1.

b. Table 2-3 illustrates the interpretation of a number of different displays in terms of the operated pushbuttons at the time.

c. Model 2480R DMM displays the true RMS value of an input waveform, within a tolerance band specified for the frequency content of the input, the crest factor of the complex waveform, and the temperature of the operating environment. A crest factor of 5 signifies that the ac to dc converter remains a linear device (no distortion of output) for waveforms where the ratio of the peak to RMS is less than 5:1

d. Model 2480 DMM displays the value in RMS of a sinusoid with the same average value as the average value of the input signal. Refer to Table 2-4 for the calibration factors to be applied for non-sinusoid inputs.

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Table 2-3
TYPICAL MEASUREMENTS

Selected Measuring Function	Selected Range	Display	Interpretation
DCV	1	+1.2345	HI input is 1.2345 volts more positive than LO input.
	100mV	−123.45	HI input is 123.45 millivolts less positive than the LO.
	100V	+123.45	HI input is 123.45 volts more positive than the LO input.
	100V	+	HI input is more than 199.99 volts more positive than LO input.
ACV	100	123.45	AC input is 123.45V RMS.
	100mV	123.45	AC input is 123.45mV RMS.
kΩ	10	12.345	Resistance is 12.345 kilohms.
	10M	12.345	Resistance is 12.345 Megohms.

2.6 APPLICATION NOTES

2.6.1 General

Optimum performance is obtained from your Model 2480/2480R DMM by observing a number of precautions in establishing the test measurement conditions. The few hints included in these paragraphs are only indicative of the types of measuring environment problems which may influence the meter performance. It is suggested that the user record his own application aids as he determines them.

2.6.2 Avoiding Ground Loops (Making Grounded Measurements)

If the line cord is connected, a potential difference may exist between the "ground" of the power source and the "ground" of the measured circuit. This difference of ground potentials may set up ground-loop currents and affect the measured values although the instrument will reduce their effects significantly (CMRR = 120dB, NMRR = 60db). The

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ground loop effects can be avoided almost completely by operating the meter on batteries.

Table 2-4 Multiplying Factors for Non-Sinusoidal Waveform Measurements.*

WAVEFORM	AVG VALUE PER MODEL	RMS VALUE	MULTIPLY DISPLAY BY
	.707A	.707A	1.0
	1.11A	1A	0.903
	.555A	.574A	1.034

*Applies to Model 2480 (average AC) only.

2.6.3 Making "Floating" Measurements

In a floating measurement, such as in Figure 2-4 it is possible to introduce a common mode voltage by reactive coupling through the AC power line when that source of power is connected. As in paragraph 2.6.2, although this effect is small, it may be avoided almost completely by disconnecting the AC power source and reverting automatically to battery power.

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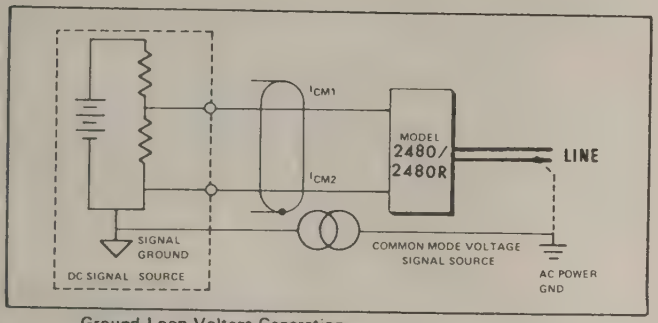
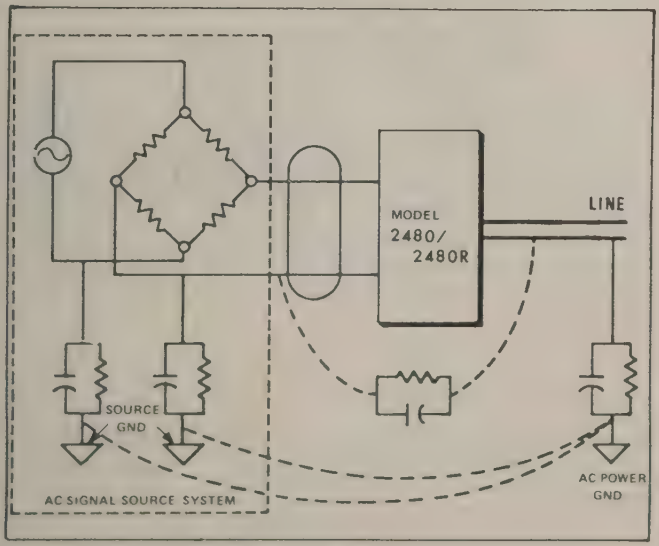


Ground Loop Voltage Generation



Induced AC Common Mode Voltages

Figure 2-4 — Avoiding Ground Loops

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2.6.4 Making High Resistance Measurements

a. When making measurements of very high impedance sources, as when required to measure resistance on the 10MΩ range, the input circuit may be susceptable to noise. The effect of voltage-producing noise fields on the probe leads may be sufficient to introduce significant changes in the least significant digit of the display.

b. Measurement errors may be kept to a minimum under these circumstances by keeping the leads as short as possible (do not use any extensions on the probes), and by twisting the probe leads so as to equalize any field effects on the signal input leads.

NOTE:

It is good practice to twist probe leads whenever possible in order to equalize any field effects on the signal input leads.

2.6.5 Making Very Low Voltage Measurements

Problems may arise when measuring very low voltages because of the differences in temperature of the probe contact points. Both probes are plated brass, and if the HI probe is in contact with copper in a high ambient temperature (for example, in a computer tape drive mechanism), while the LO probe is grounded at a very much cooler steel cabinet frame, then a difference in emf of several hundred microvolts may result, changing the least significant digit. In order to minimize such errors, connect the probes wherever possible at approximately the same temperature.

2.7 OPERATOR SERVICING

a. Operator servicing of Model 2480 2480R DMM is limited to replacement of fuses, and installation of accessory rechargeable battery assembly.

WARNING

Unplug the line cord from ac source and from Model 2480 2480R DMM before attempting to replace fuse or install battery assembly.

b. Fuse Replacement Table 2-5 identifies the fuse data, while Figure 2-3 indicates their location in the rear panel. To replace, unscrew fuse holder; remove spent fuse; replace in fuse holder; screw into panel.

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c. Battery Installation Battery assembly, C48, is installed by sliding the battery case into the vertical channels on the interior rear panel. Contact is made with two clips mounted on the main board behind the rear panel. To install, remove top cover by removing two top screws in rear panel, lift top cover rearward and slide out; install battery assembly.

WARNING

Access to Battery Assembly requires removal of cover and exposes high voltage terminals. Unplug power cord before removing cover.

Table 2-5
FUSE REPLACEMENTS

Ref. Designation	Description	Function	Data Precision Part Number
F301	2A 250V 3AG	Protection for high current inputs on ranges from 100μA to 2A.	25-500002
F300	1/16A 250V 3AG SLO-BLO	Line Fuse. Protection for power shorts.	25-500008

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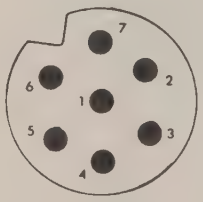
J302



J302	SIGNAL NAME	FRONT PANEL
1	Input Signal (+)	J400 (HI)
2	Input Signal (−)	J401 (Lo)
3		
4		
5		
6		
7	Shield	

Rear Panel Signal Connections

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Chapter 3
CALIBRATION

3.1 GENERAL

a. The Model 2480/2480R Digital Multimeter is factory calibrated and burned-in prior to shipment, and is designed to remain in calibration for a minimum of 1 year before the recalibration procedure should be required. The complete set of factory test data sheets for each instrument is shipped with the meter and should be referenced to determine the need for calibration.

b. Once calibrated, Model 2480/2480R DDM does not require any **operating zero** adjustment on any measurement function or any range scale, and no front panel adjustment is provided.

3.2 CALIBRATING ADJUSTMENTS

a. The adjustments to calibrate Model 2480/2480R DMM are accessible through access holes in the shield after removing the top cover of the case. Table 3-1 identifies the adjustments and their function. To remove the cover, remove the two top screws in the back plate, lift the top rearward from the front bezel, and slide out. Figure 3-1 indicates the major assemblies and points out the adjusting components listed in Table 3-1. Their reference designators are indicated on the top of the analog shield.

b. When calibration is required, test standards of the ranges and accuracies listed in Table 3-2 should be used to eliminate any test standard uncertainty.

3.3 CALIBRATION PROCEDURES

a. Allow the instrument to warm up for one-half hour before beginning the recalibration.

b. Perform the adjustments in the sequence of Table 3-3. Apply test input standards of amplitude and frequency as close as possible to the values listed. Adjust the designated control until the display is the input

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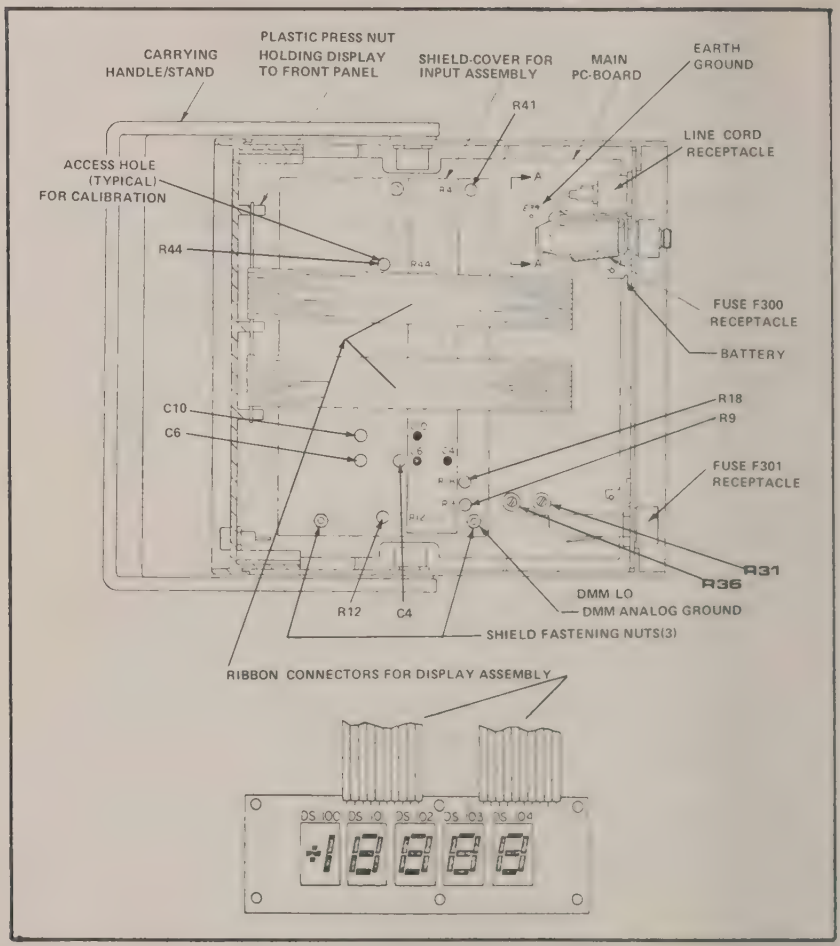

Figure 3-1

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(or the designated reading). If available test standards do not develop the listed values, then the closest value to the specified input should be used and the control adjusted accordingly. It is desirable to use signals at least 50% of the full scale value for the specified range.

c. When calibration is complete, reassemble the unit by replacing the top cover in reverse sequence of paragraph 3.2.

Table 3-1
CALIBRATION ADJUSTMENTS

REF. DES.	NAME	FUNCTION
R31	DCV: 1 volt	Adjusts 1-volt Reference Voltage
R36	DCV: 100mV	Adjusts 0.1-volt Reference Voltage
R44	(Model 2480) ACV	Calibrate AC/DC gain
R18	(Model 2480R) ACV	Calibrate AC/DC gain
R9	" ACV	and offset
R12	ACV	Calibrate AC/DC gain
C6	ACV 10kHz	Calibrate ACV Frequency Response
C4	ACV 10 kHz	Calibrate ACV Frequency Response
C10	ACV	Calibrate ACV Frequency Respone
R41	DCV Zero	Adjusts zero offset

Table 3-2

PARAMETER	RANGE	ACCURACY TOLERANCES
DC Voltage	0 to 10V	±0.005%
AC Voltage		
@ 500Hz	0 to 10V RMS	±0.01%
@ 10kHz	0 to 1000V RMS	±0.02%

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Table 3-3
CALIBRATION PROCEDURE*

Step	Select Function	Select Range	Connect Test Input	Adjust For Input Or Record
1	DCV	100mV	0	R41 for ±00.00
2	DCV	1V	+1.9000V	R31 for +1.9000
3	DCV	100mV	+190.00mV	R36 for +190.00
4	ACV	1V	5mV @ 100 Hz	Model 2480: None; Model 2480R: R9 for .0050
5	ACV	1V	1.5V @ 100 Hz	R44 for 1.5000 R18 for 1.5000
6	ACV	100mV	150mV @ 100 Hz	R12 for 150.00
7	ACV	1000V	1000V @ 10 kHz	C6 for 1000.0 C4 for 1000.0 if C6 Adjustment does not display 1000.0
8	ACV	100V	100V @ 10kHz	C10 for 100.00
9	ACV	10V	10V @ 10kHz	Record
10	ACV	10V	10V @ 10kHz	C4 until display is half distance between value in (9) and 10.000
11	ACV	1000V	1000V @ 10kHz	C6 for 1000.0 (see Step 12)
12	ACV	Repeat steps 10 and 11 until 10V @ 10kHz input results in display between 9.985 and 10.015		

*Procedure is same for Model 2480 and Model 2480R except as noted in steps 4 and 5.

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Chapter 4
PRINCIPLES OF OPERATION

4.1 GENERAL

a. Model 2480 Series Digital Multimeter converts input signals into digital displays using the integrating dual slope technique in a patented Tri-Phasic A/D converter circuitry, employing Iso-Polar referencing and Ratiohmic circuit configuration for resistance measurements.

b. The multimeter is triggered internally to initiate a 3-phase measurement cycle. During Phase 1 the meter circuits are automatically servoed to determine the correction for the accumulated zero offsets in the analog integrator loop. In Phase 2 the signal to be measured, which has been conditioned according to the type of signal (AC, DC, or Ohms) and selected range scale, is compensated for the zero offset correction to the dual slope A/D converter integrator which integrates the conditioned input for a fixed time interval of 100 milliseconds. After the fixed time interval of Phase 2, Phase 3 begins, in which the input signal is disconnected from the A/D converter, and in its place a reference signal of opposite polarity and fixed magnitude is also compensated for the zero offset correction. The integration of the reference signal continues in Phase 3 until this second ramp of the dual ramp A/D converter reduces the voltage at the integrating output to zero. The zero level is sensed and indicates the End of Conversion (EOC) if it occurs in 200 msec or less during Phase 3. If there has not been a EOC signal within 200 msec in Phase 3, the meter interprets this as an out-of-range condition. The meter reduces the remaining voltage at the integrator output via a fast time discharge and at EOC initiates Phase 1 to restart the conversion cycle. The fast capacitor discharge circuit assures that the auto-zeroing integration in Phase 1 will start from zero conditions after an out-of-range input, and that there is no residual voltage offset at that time. The out-of-range sense circuit also initiates the development of logic control signals for the out-of-range display.

4.2 OVERALL BLOCK DIAGRAM & SYSTEM TIMING

As shown in Figure 4-1, Model 2480 DMM consists of essentially six main functional groups.

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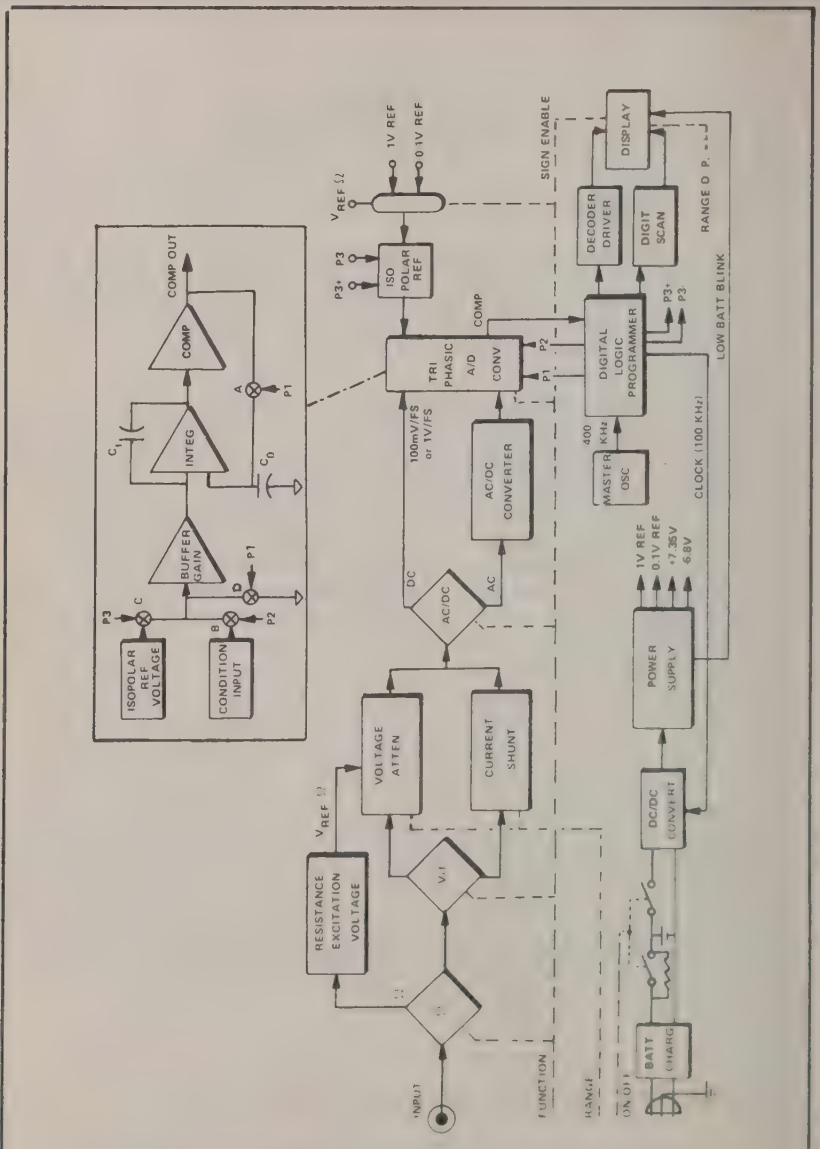

Fig. 4-1. Overall Block Diagram

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a. Input Signal Conditioners (Excitation, Dividers, Shunts, AC/DC Converter).
b. Tri-Phasic™ Analog-to-Digital Converter.
c. Digital Logic Programmer and Master Timing Oscillator.
d. Isopolar Reference Generator.
e. Display (Decoder and Scanner).
f. Power Supply (Including DC/DC Converter and Reference).

4.2.1 Input Signal Scaling

a. The output count n, of the Tri-Phasic A/D converter is determined by the formula

$$n = K \frac{V_{COND}}{V_{REF}}$$

where n = The count accumulated in the output register during Phase 3;

V_{COND} = The conditioned voltage amplitude input to the A/D Integrator during Phase 2;

V_{REF} = The reference voltage amplitude input to the A/D Integrator during Phase 3; and

K = scaling constant, determined by the Duration of P2 in counts

Thus, as shown in Figure 4-1, the digital value will be scaled by the combined effects of the input voltage attenuator or current shunt, the gain through the AC/DC converter (for AC inputs), the selected reference voltage amplitude, and the gain of the buffer ahead of the integrator A/D. Table 4-1 summarizes the relationship of the gain factors for each range and in each function mode.

b. An input voltage signal is conditioned by the voltage attenuator and an input current by a current shunt. The development of a conditioned voltage across an unknown input resistance is described in detail in a subsequent paragraph.

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Table 4-1
MODEL 2480/2480R
GAIN FACTOR TABLE

Measure Mode	Range Selected	Input Atten/Shunt	AMP + AC to DC GAIN	Selected DC Ref Voltage Amplitude	A/D Input AMP
DCV	100mV	1:1	NOT USED	0.1	10:1
	1	1:1		1	1:1
	10	1:10		1	1:1
	100	1:100		1	1:1
	1K	1:1000		1	1:1
ACV	100mV	1:1	10:1	1	1:1
	1	1:1	1:1	1	1:1
	10	1:10	1:1	1	1:1
	100	1:100	1:1	1	1:1
	1K	1:1000	1:1	1	1:1
ACmA	100mV	1:1	10:1	1	1
	1	1:10	10:1	1	1
	10	1:100	10:1	1	1
	100	1:1000	10:1	1	1
	1K	1:100000	10:1	1	1
DCmA	100mV	1:1	NOT USED	0.1	10:1
	1	1:10		0.1	10:1
	10	1:100		0.1	10:1
	100	1:1000		0.1	10:1
	1K	1:100000		0.1	10:1

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4.2.2 Tri-Phasic A/D Converter

The analog section of the Tri-Phasic Analog-to-Digital Converter includes an input buffer stage of selectable gain, integrator, and comparator, connected as shown in a very simplified schematic of Figure 4-1. They function as follows during the three phases of Tri-Phasic operation.

a. Phase 1

During Phase 1 the analog section automatically zeros the unit to correct for the zero offsets inherent within the analog functioning elements. During this phase, switch A and switch D are closed, removing the conditioned input, and closing the loop around Integrator and Comparator. As a result, the closed loop servos the output of the A/D comparator to near-zero. At that time a voltage will have been developed across the memory capacitor, C_o which balances the sum total of all the individual offsets generated within the loop, and the servo loop "sees" a zero error signal.

b. Phase 2

At the start of Phase 2, switches A and D open, and switch B closes. In the open position of switches A and D, the analog section retains the offset voltage on memory capacitor C_o as a correcting value which will be combined algebraically with the input signals and the values integrated in Phase 2 and Phase 3.

Switch B, which remains closed during Phase 2, connects the input signal conditioner output to the buffer amplifier. The buffer output is integrated for a fixed time of 100 milliseconds as controlled by the digital logic. The voltage developed across the integrating capacitor C_i is therefore proportional to the magnitude of the input signal, and the output of the high-gain comparator amplifier will be at a saturation level of the same polarity as the conditioned input voltage.

c. Phase 3

At the start of Phase 3, switch B opens, removing the conditioned output signal from the unity gain amplifier. At the same time (start of Phase 3), the polarity sense function of the digital section determines the polarity of the comparator output and transmits a control signal to the Isopolar reference switching network, thereby connecting the correct polarity of the reference voltages through Switch C to the unity gain amplifier for

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integration during Phase 3. The reference voltage integrated during Phase 3 decreases the voltage across integrating capacitor C_I until the output of the high gain comparator changes polarity. This change in comparator output polarity indicates end of conversion and is sensed in the logic to indicate the end of Phase 3 and the start of Phase 1. The cycle repeats.

If the charge on C_I is not reduced to zero in the 200 msec allowed for full overrange measurements, the digital control logic initiates the out-of-range actions in the multimeter, as explained later. It should be noted that the zero offset is generated and the storage capacitor charge is updated in each conversion cycle. Also, note that the stored voltage representing the corrected zero is introduced into the analog section for both the unknown integration and the reference integration, thereby removing the zero effects from both the charging and the discharging actions on C_I.

The timing relationships of the Triphasic conversion cycle are summarized in Figure 4-1A.

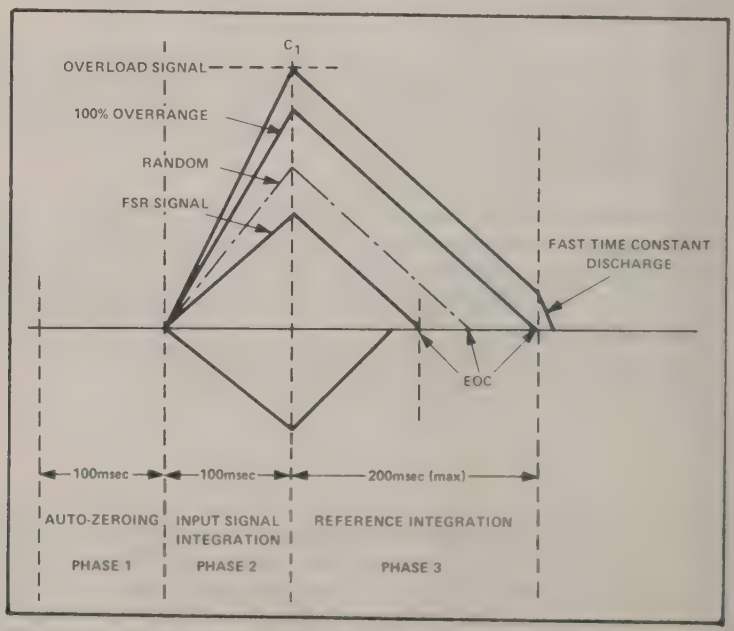

Fig. 4-1A **System Timing Waveforms**

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4.2.3 Digital Logic Programmer

a. All of the logic circuitry to develop the phase timing control signals for the A/D converter are incorporated in one CMOS integrated circuit. This component receives the 400 kHz master oscillator pulse chain from which it derives the control signal for the start of Phase 1, the start of Phase 2 (100 milliseconds later) and the start of Phase 3 (100 milliseconds after the start of Phase 2). It also receives the A/D comparator output from which it derives the control signals to select the polarity of the reference for Phase 3 signal integration and the control signal that ends Phase 3.

b. The logic chip also generates the control signal for the fast discharge of the integrating capacitor, if applicable, and the control signals that cause the out-of-range indication in the display.

c. The digitized value of the conditioned multimeter input is time multiplexed in BCD format on four parallel lines to the Decoder Driver, while the corresponding digit address is transmitted to the address scan element.

4.2.4 Decoder/Driver and Display

a. The digitized value of the conditioned input is converted from the BCD format into 7-segment display code in a CMOS Decoder/Driver. The Decoder/Driver outputs provide adequate current to drive directly the segment of each digit display. The decoder unit also receives the blanking control output from the digital programmer (paragraph 4.2.3) and responds with the blanked display format of an overload indication.

b. The display consists of four full decades of seven-segment characters, a fifth element which may take a character of "1" or remain blank, and an element for indicating the polarity of the input signal. The decimal point position is controlled directly by the manual range selection, and may be located in any one of four positions.

4.2.5 Reference Generator

The Iso-polar™ reference generator provides a precise 1.0 or 0.1 volt level to be connected to the analog input for Phase 3 operation. The selection of 1.0 or 0.1 voltage level is accomplished by the mode selection. The Iso-polar action obtains positive or negative references with equal magnitudes.

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4.2.6 DC/DC Converter & Power Supply

a. Power for the meter is obtained from a built-in battery charger, provided as standard equipment that maintains >6.8V voltage whenever the charger is connected to line power, whether or not the meter is on. The DC/DC converter is connected to the battery supply only when the meter is turned ON, and develops nominal +7.35 volts for the analog circuitry. The 6.8 volts for the digital logic and for the analog amplifier units are supplied directly by the battery.

b. The reference voltage generator regulates the +7.35 volt output of the DC/DC converter, and develops both the +1 and 100mV reference potentials for use in the A/D conversion. The isopolar reference circuitry determines the appropriate polarity of these levels before connection to the A/D converter in Phase 3. Additional circuitry monitors the level of the negative supply and causes the decimal point to blink when a low-battery condition exists.

4.3 INPUT SIGNAL CONDITIONING DETAILS

4.3.1 Voltage Attenuator

a. Model 2480/2480R DMM scales all ac and dc voltages in a frequency-compensated voltage divider, as shown in the fold-out reference schematic. Parts of the divider are also used as the reference resistance for the Ratiohmic resistance measurement. The decimal point location automatically tracks the decade selection effected by the range switch.

b. Resistance elements of the divider are contained in a single resistor network, A4, that has been trimmed during manufacture to within 0.03% relative and absolute accuracy. Capacitive elements that trim the network for specified frequency response are mounted external to the resistor network.

4.3.2 DCV Signal Conditioning (Figure 4-2)

When the Function Switch is in the DCV position, the output of the voltage attenuator is direct coupled to the A/D converter through Q7 during Phase 2 of the 3-phase conversion cycle. Resistors R7, R8 and capacitor C25 form a single pole input filter for all dc input signals.

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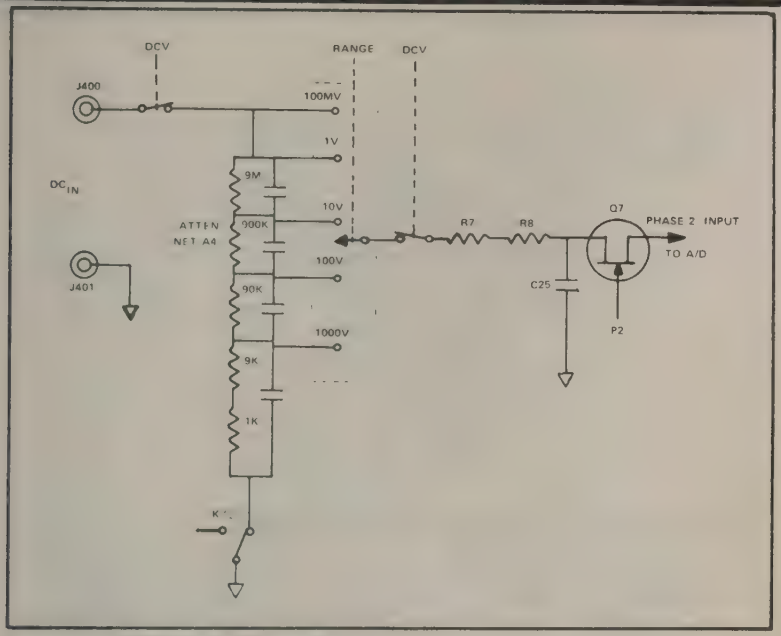

Fig. 4-2 DCV Signal Conditioning

4.3.3 ACV Signal Conditioning (Figures 4-3, 4-4, 4-5)

a. When the Function Switch is in the ACV position, the output of the voltage divider is connected to the AC DC converter. The AC DC converter is preceded by an amplifier of selectable gain (1:1 or 1:10).

b. The AC DC converter is connected in the circuit through contacts of the function switch ACV or ACmA, and receives the output of the voltage attenuator or current shunt, respectively. The gain of amplifier Z4 is either unity or 10, determined by the configuration of the feedback circuit that is controlled by the selected function and range. A gain of 10:1 is set up for all ranges when in ACmA measurements, or when the 100mV RANGE is selected for ACV measurements. The 10:1 divider ratio is obtained by resistors R13 and R14 and trimmed by series potentiometer R12 for calibration purposes.

c. In Model 2480 DMM, the output of Z4 is capacitor-coupled (C14) to the averaging circuit. See Figure 4-4. The output of Z8 is half-wave rec-

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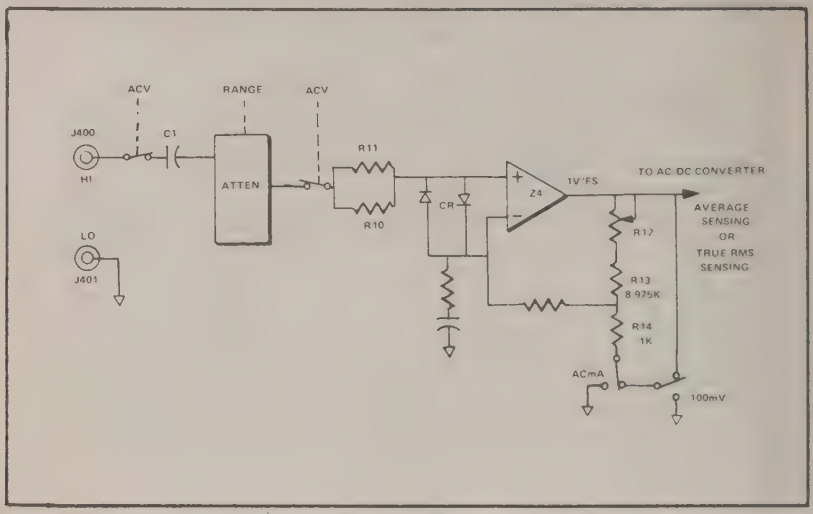

Fig. 4-3 Scaling the ACV Input to AC/DC Converter

tified and filtered (C18, R61, C16) so that the scaled dc voltage is calibrated for the rms value of a sine wave with equivalent average value. The feedback network around Z8 introduces the correct scaling factor, while R44 is a calibrating adjustment for the circuit operation.

d. In Model 2480R, the ac output of Z4 is capacitor-coupled (C20) to Z9, in which it is converted to a dc voltage and scaled such that 1VRMS at Z9-1 produces 1VDC at Z9-8. The scaling of Z9 is adjusted by R18 for calibration.

4.3.4. Current Shunt & Current Input Conditioning

a. When in either DCmA or ACmA position, the Function Switch connects the input signal to a decade current shunt R1 through R5. Shunt values are selected so that the output will be 100mV for nominal range inputs. Diode ring CR5 through CR9 provides a protection against overload input to keep the shunt voltage outputs within ± 2V.

b. When in DCmA position, the Function Switch couples the shunt output to the A/D converter, as for DCV operation.

c. When in ACmA position, the Function Switch connects the shunt output to the AC DC converter and the AC DC converter output to the A D input as for ACV operation.

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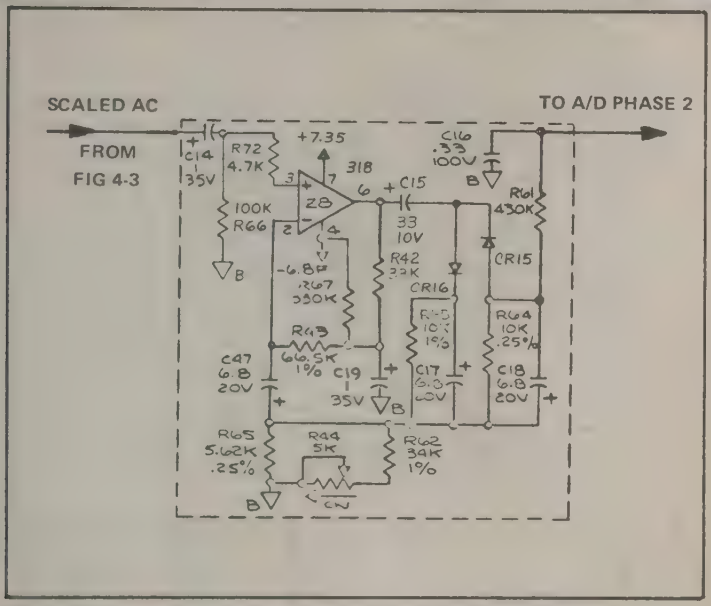

Fig. 4-4 Model 2480 AC/DC Average Sensing Conversion

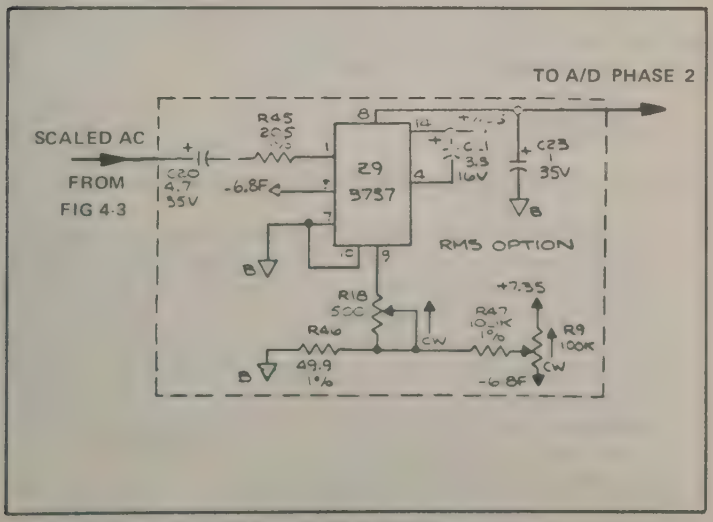

Fig. 4-5 Model 2480R True RMS AC/DC Conversion

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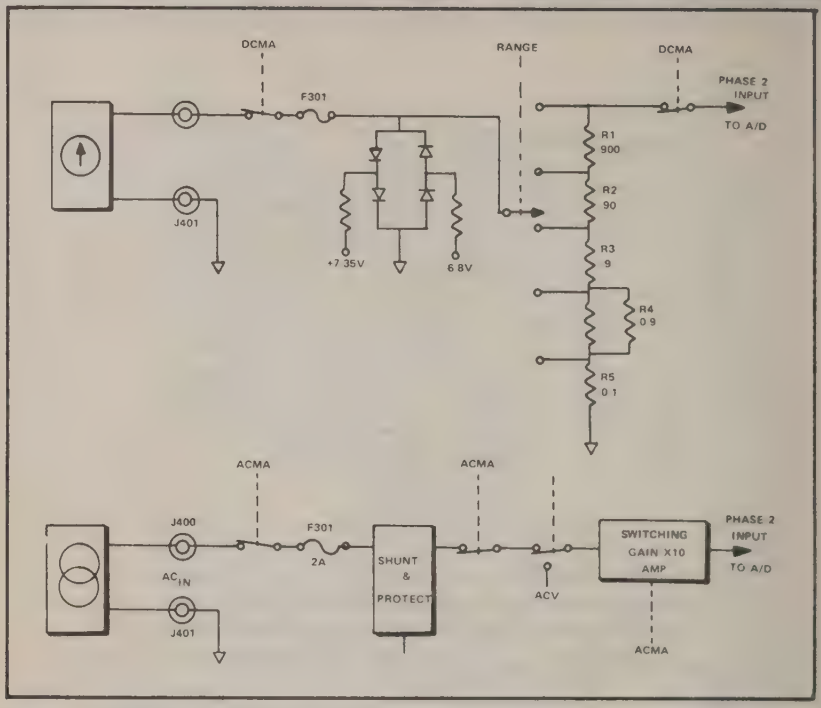

Fig. 4-6 Signal Conditioning Current Inputs &
(a) DCmA
(b) ACmA

4.3.5 Resistance Measurement Signal Conditioning

a. In the Data Precision Ratiohmic technique of resistance measurement, the resistance to be measured is connected in series with a selected standard resistance and driven by a source voltage so that the voltage input to the A/D for Phase 2 and the voltage input to the A/D for Phase 3 are derived from the action of the same current in the circuit. Because the Tri-Phasic technique digitizes the ratio of the two voltages (see paragraph 4.2.1), the exact value of the current is not significant in determining results, only its stability over the measurement cycle. Figure 4.7 is a simplified schematic illustrating the Model 2480 2480R operation when in Resistance measurement mode.

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b. As shown in Figure 4-7, selection of kΩ by the Function Switch applies a nominal 2V across the series-connected unknown resistance and the range-selected precision standard resistance. (The standard resistance is selected from the voltage-divider precision resistor network described previously in paragraph 4.3.1). The voltages for Phase 2 and Phase 3 are generated by the current, I , whose value is determined by the series combination of the two resistances.

c. The voltages connected to the A/D input are controlled by the switch closures of Q7,Q8, Q11, and Q12. During Phase 1, C27 is charged to the value Vs + Vx by the closing of Q8 and Q12. The input to the A/D is zero because of the closing of Q8. During Phase 2, Q8 and Q12 open, Q7 closes, and the input to the A/D is Vx. During Phase 3, Q7 opens, and Q11 closes connecting the high side of C27 to -Vx. The low side of C27 is thus Vx - (Vx + Vs), or Vs, and that value is the input to the A/D. The dual slope integration digitizes the ratio Vx/Vs. But Vx = Is ·Rx, and Vs = Is·Rs, so that the measured value is the ratio Rx/Rs, as required. (Q6 remains open for all phases in Resistance Measurement mode.)

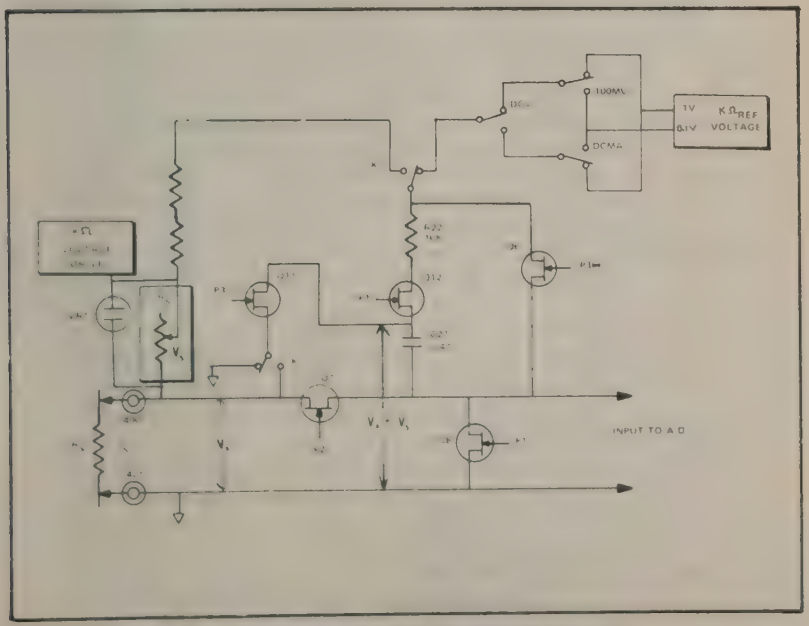

Fig. 4-7 Resistance Signal Conditioning and Iso-Polar Reference Generation

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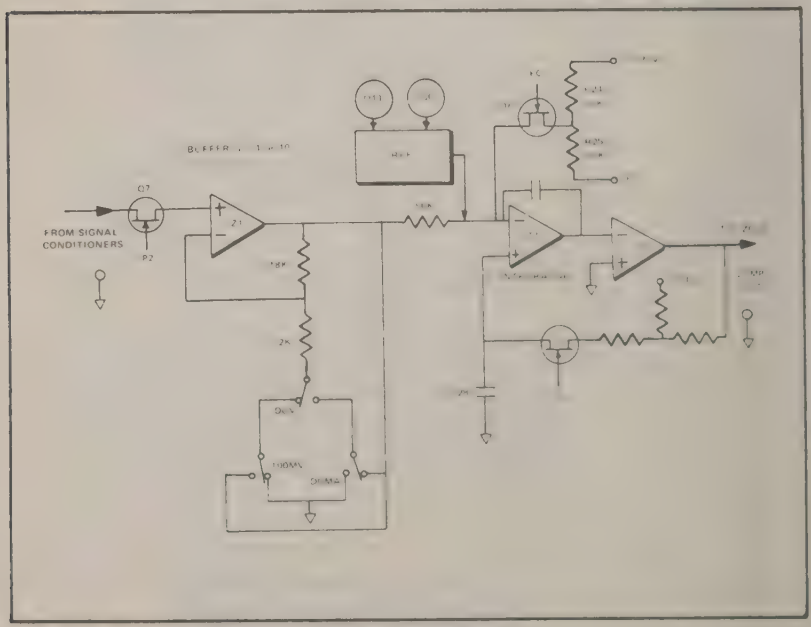
d. Voltage regulator, VR1, is placed across the standard resistance network to protect it against high voltages if a fault should develop.

e. The circuitry that generates the excitation voltage used for resistance measurement is shown in detail in the fold out reference schematic. The three pass transistors Q1, Q2, and Q3 and diode CR18 are used to develop the nominal 2 volts to excite the series input of resistance to be measured and range-selected precision standard resistance. The pass transistors provide a breakdown limit of 3 × 300V peak for protection of the specified 450 VRMS value, while FET transistor Q4 is connected as a voltage clamp.

4.4 TRI-PHASIC A/D CONVERTER DETAILS

a. Figure 4-8 identifies the A/D circuitry containing active elements Z1, Z2 and Z3. Amplifier Z1 is connected as a programmable gain non-inverting amplifier, whose gain is determined by the switched components in the feedback circuit. In DCmA and in the 100mV Range of DCV measurement function, the 18K and 2K resistors of the A1 network are



4-14 **Fig. 4-8 Tri-Phasic Analog to Digital Converter**

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connected as a voltage-divider to ground with a 1:10 feedback ratio. Amplifier Z2 is connected as an integrator with C30 = 1μF and the 50KΩ resistor of network A1 determining the charging current. Amplifier Z3 is connected as a high-gain inverting comparator, sensing the polarity of the Z2 output with respect to ground.

b. During Phase 1, Q9 is closed, connecting the comparator output to the noninverting integrator input, and servoing any non-zero signals generated in the active elements to charge capacitor C28 with a voltage balancing the non-zero effects. Phase 1 lasts for 100 to 300 milliseconds.

c. During Phase 2, Q7 is closed, connecting the conditioned input to the A/D converter. If the measuring function is DCmA (any Range) or DCV (Range 100mV), then nominal full scale input will be 100mV at the input to Z1. The gain around Z1 will then be 10:1, so that the integrating capacitor will be charged with the same current as for nominal 1 volt inputs. Scaling for 100mV inputs then takes place by using the 0.1VDC reference voltage during Phase 3.

d. During Phase 3, Q7 opens, removing the conditional signal input, while the closing of Q11 or of Q6 applies a negative or positive reference, respectively, to the A/D input. (See paragraph 4.5.) The reference magnitude is determined by the Function and Range switch selections, as previously shown in Table 4-1. The charging path for C30 remains as set up for Phase 2, and the circuit reduces the voltage on C30 while the digital counter in Z6 digitizes the measured value. Phase 3 lasts until comparator Z3 indicates the zero crossing of the C30 voltage by a change in polarity at the output. The comparator output charge is sensed in Z6 and results in the generation of the Phase 1 control signals to start the autozero actions of the next conversion cycle.

e. If the integrator zero-crossing does not occur within 200 msec in Phase 3, then the digital logic will generate appropriate out-of-range blanking indications and will generate the FC active control signal to close switch Q10. If the conditioned output is an out-of-range positive value, P3-( ) will be negative, and a negative current will be introduced at the integrator input to reduce the remaining capacitor voltage more quickly to zero. If the conditioned input is an out-of-range negative value, P3-( ) will be positive, and a positive current will be introduced at the integrator input to reduce the remaining capacitor voltage to zero as before. This action assures that the integrator capacitor voltage will be at zero at the start of Phase 1 autozeroing action.

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4.5 ISOPOLAR REFERENCING

a. Figure 4-7 included a simplified schematic of the isopolar reference generation circuit. The Function Switch and Range Switch combination selects either +1.0 V or +0.1 V according to the conditions of Table 3-1.

b. During Phase 1, Q12 and Q8 are closed, charging C27 to the 100mV or 1V reference value. During Phase 3, if a negative reference is required (positive conditioned input) Q11 closes, placing the high side of C27 at ground level. As a result, the negative side of C27 is negative by the magnitude of the voltage on C27. If a positive reference is required (negative conditioned input), then Q6 is closed, connecting the positive reference as input to the A/D converter.

4.6 DIGITAL LOGIC PROGRAMMER & MASTER OSCILLATOR

a. The digital logic programmer circuitry is contained entirely on one CMOS solid state component, Z6. It contains (Fig. 4-9):

4-Decade Counter and the MSD flip-flop
Latching BCD Output Register
Clock Generator
A/D Phase Signal Generator and Fast Charge Control
Polarity and Overload Detection Logic

b. In addition to the phase control signals described earlier, digital logic Z6 outputs the latched register BCD values series-by-digit, parallel-by-bit on 4 BCD output lines. The digit address for the BCD data is indicated as a high level on one of 4 parallel lines, while separate lines indicated the binary value of the MSD (0 or 1), and the polarity (binary + or −). The binary out-of-range condition is also indicated on a separate Z6 output line.

c. The master clock oscillator circuit containing resonator Y1 oscillates at 400 kHz. This frequency is counted down by 4 in Z6 to obtain a basic counting rate of 100 kHz so that the carry from the 4-decade counter represents an interval of 100 milliseconds for Phase 1 and Phase 2 timing. An MSD divide-by-two flip flop at the output of the 4-decade counter is used to sense the MSD of 10^4 counts, and, when digitizing an out-of-range input to the A/D, senses 2×10^4, from which the blanking control and FC control signals are developed.

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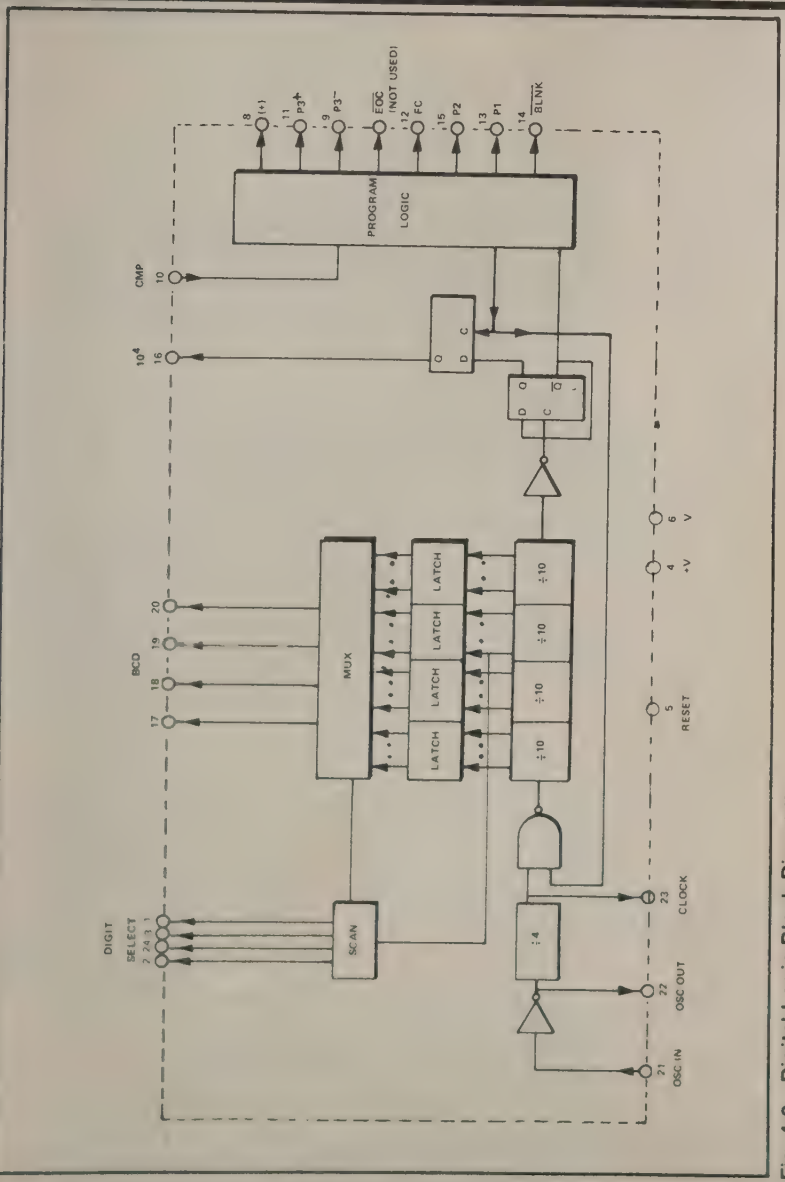

Fig. 4-9 Digital Logic Block Diagram

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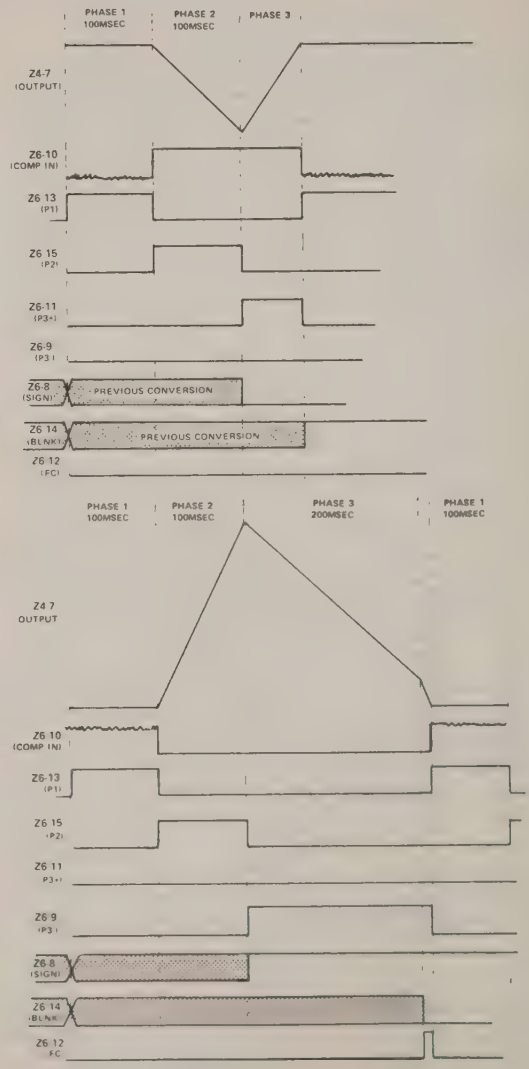

Fig. 4-10 Digital Logic Timing Waveforms

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d. Decoder/Driver Z10 receives the latched outputs in BCD format, time multiplexed on 4 parallel lines successively for each of the four full decades. It converts these to appropriate seven-segment outputs for the LED display digits.

e. Figure 4-10 is a summary of the timing relationships of the waveforms generated in Z6. Conditions for converting an in-range A/D negative input are shown in the upper portion and for an out-of-range positive input in the lower portion of the illustration. The SIGN output of Z6 is always produced; whether the polarity is displayed is determined by an enabling signal controlled by the setting of the front-panel Function Switch.

4.7 DISPLAY

a. The display is assembled on a separate PC card. It contains the five display digits, including sign and decimal points. Current limiting resistors for the segment drivers of the four full decades, transistor driver circuits for the most significant "1" (when appropriate), and for the polarity (plus or minus) are installed on the main assembly PC-card. Digit address enabling signals multiplex the full decade digits DS102, DS103, DS104, and DS105 through transistor switches Q20, Q21, Q22, Q23, respectively. A control signal from the main PC board assembly enables the polarity display when in DCV or DCmA measuring function. Range-selected control signals drive the decimal point in the appropriate decade through limiting resistors.

b. The display indicates a low battery (or low line voltage when no battery is installed) by blinking the decimal point. Figure 4-11 is a simplified schematic illustrating how this operation is performed. Amplifier Z3-1 is configured as a comparator for the battery voltage and the 0.1V REF. When the battery voltage is less than the reference value, its inverted output at Z3-1 enables Q16. Program control signal P1, which has a nominal frequency of 2.5 Hz, interrupts the LED supply voltage at that frequency.

4.8 DC/DC CONVERTER & POWER SUPPLY (See Reference Fold Out)

a. The DC DC Converter is a switching regulator type, triggered by a 100 KHz pulse train from digital programmer Z6. Transistor Q17 switches the current through L1 and CR12. When Q17 is off, the current in L1 continues to flow through CR12 and charges capacitor C40 to approximately 10V.

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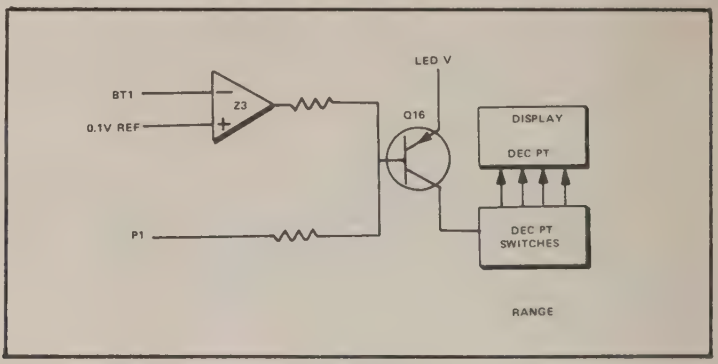

Fig. 4-11 Low Battery Sensing Schematic

b. Amplifier Z5-1 and reference zener CR1 are connected in a voltage regulator circuit that results in a regulated +7.35V with respect to reference ground. Voltage divider network R31, R32, R33, R34, R36, R37 and R38 are used to develop the +1V and +0.1V reference levels for the Phase 3 A/D integration. R31 and R36 are the calibrating adjustments for these voltages.

c. Amplifer Z5-7 is configured as a voltage follower to establish the reference ground for instrument use.

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Chapter 5
MAINTENANCE

5.1 GENERAL

CAUTION

Your Multimeter is covered by a one-year warranty and should be referred to the factory for maintenance within the warranty period. Attempts to make any extensive repairs within the warranty period may invalidate the warranty. If repairs are needed after the warranty period, only qualified technicians should attempt to effect such repairs and should use test instruments and standards calibrated within the accuracy and tolerances of the specifications.

5.2 TROUBLE-SHOOTING FLOW CHART

Should the meter performance indicate a possible need for repair, a well-defined strategy should be used to isolate the cause of trouble. This is illustrated in Figure 5-1. It indicates a sequence of steps in terms of standard symbols and defines a program of actions based on a philosophy of positive maintenance. The positive approach isolates to the faulty sections by verifying proper operation of the remaining instrument sections.

5.3 TEST POINTS

The test sequences identified in the chart of Figure 5-1 are described in step-by-step detail in the paragraphs that follow. In performing the tests detailed in these paragraphs, the maintenance technician is directed to make measurements at designated test points at significant portions in the circuit, identified by E-reference numbers. Other test points designated in the test procedure paragraphs may be pin terminals of circuit components, and technicians should refer to component data sheets for the pin terminal locations. Use caution in attaching test leads to avoid accidental shorting of adjacent components. The use of EZ Mini Hook®, or equivalent is suggested to aid in making good connections

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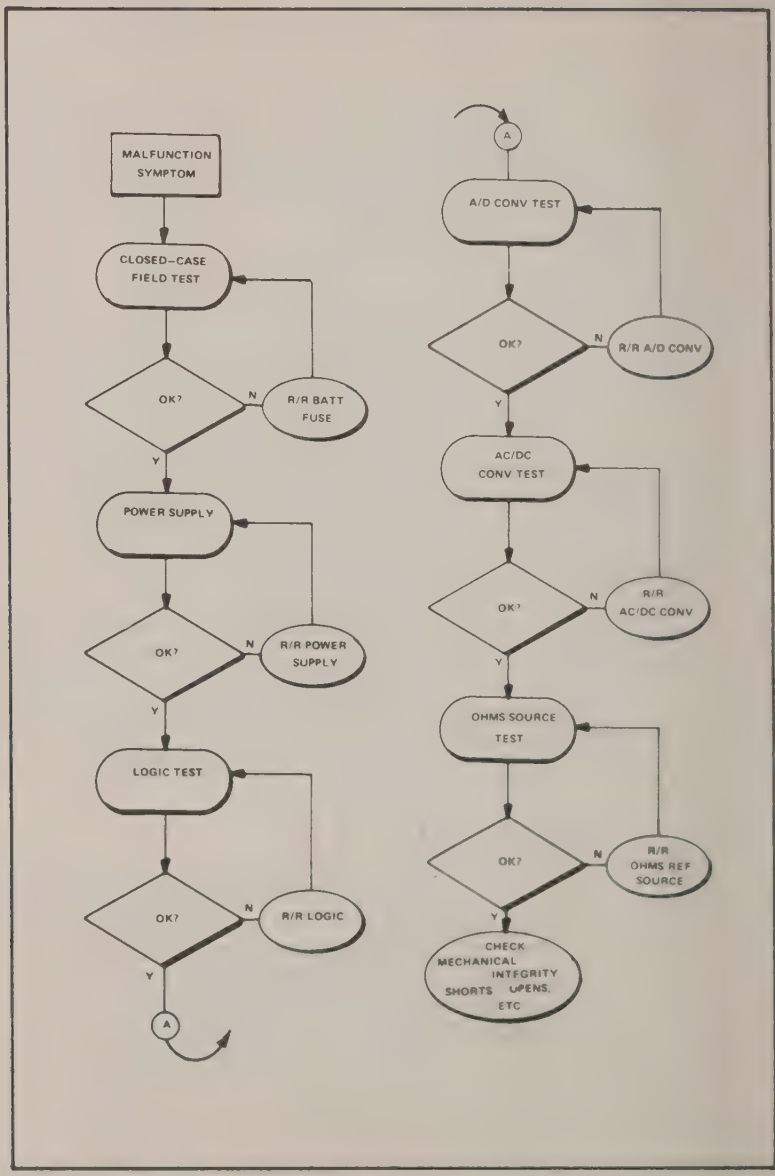

Fig. 5.1 Overall Test Strategy

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5.4 FIELD (OPERATOR) MAINTENANCE

a. Field (operator) maintenance is limited to replacement of fuses or battery pack assembly.

WARNING

Disconnect signal inputs and ac line cord before performing any replacement.

Figure 5-2 illustrates the logical sequence to be followed in identifying a fuse or battery as the probable cause of any malfunction symptom.

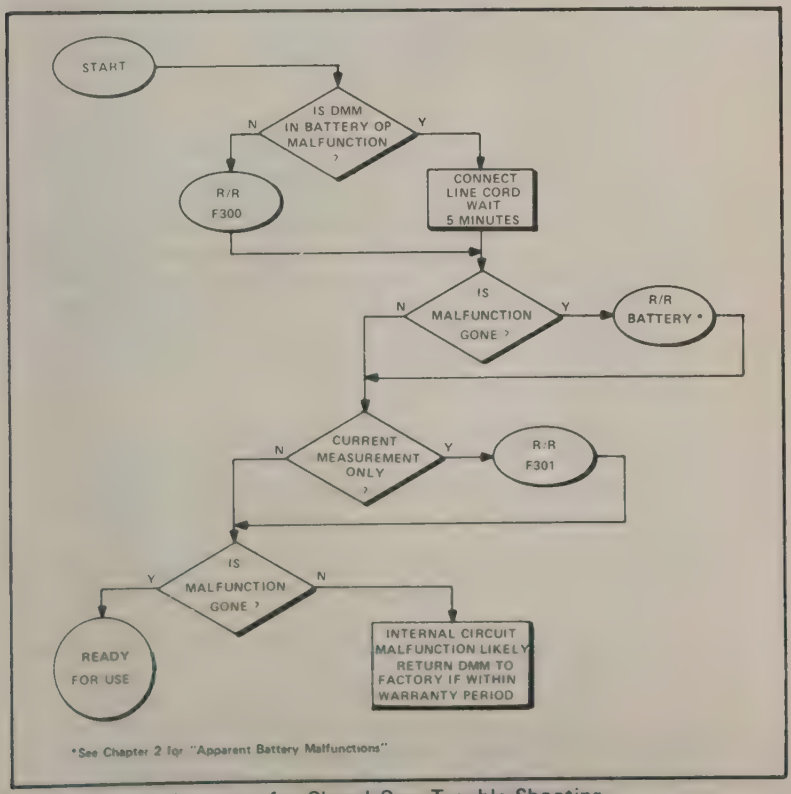

Fig. 5-2 Logic Sequence for Closed Case Trouble Shooting

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NOTE

Refer to Chapter 2, Operation, regarding temporary battery malfunction and recovery procedures.

b. Battery assembly replacement is accomplished after removing the top cover of the case.

(1) Disconnect line cord (if used)
(2) Disconnnect input signals from front panel
(3) Remove fastening screws (2) identified in Figure 2-3 as item 1.
(4) Lift top cover. Remove.
(5) Slide battery assembly up and out.
(6) Replace and follow reverse steps and replace cover.

5.5 OPEN-METER TEST/MAINTENANCE

5.5.1 General

If the multimeter does not perform correctly after the field tests are satisfactorily completed, then it is likely that repairs to an internal assembly are required. The sequence of such tests is indicated in the overall strategy of Figure 5-1. Each test sequence paragraph includes the designation of test points, the indicators of proper performance, the circuits that are checked when proper performance is observed, and the circuits that should be examined in greater detail when indications of improper performance are recorded. Refer to the fold-out schematic in the back of this manual for complete circuit details, and to Chapter 6 for replacement parts identification.

5.5.2 Access to Meter Assembly Within Case

a. The meter assembly is contained on one main PC board. To obtain access to the assemblies and components, proceed as follows:

(1) Remove top cover of case as described in paragraph 5.4. This will expose major assemblies as shown in Figure 3-1.

(2) Remove the plastic push-nuts holding the display flex assembly to the front panel assembly.

(3) Lift up display assembly. The ribbon connector cable may be bent back to permit access to components beneath the cable without having to unsolder the cable at the main board. This will also allow the display assembly to function during tests.

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(4) Remove the 3 fastening nuts, holding the analog shield in place.

Note: The post marked DMM LO in Figure 3-1 may be used as a reference ground connection for appropriate measurements and waveforms during the trouble-shooting procedure.

Figure 5-2 indicates the location of circuit components that are accessible after removal of the analog shield.

b. Applying Power to the Multimeter.

The meter may be powered from a battery assembly, or line charged battery assembly, or from line power alone. When using live power, care should be taken when making tests near transformer T1 to avoid contact with high voltage there and at the line fuse terminals. If a battery is to be used, make sure that a fully charged battery pack is available before performing any trouble shooting procedures.

5.6 TEST EQUIPMENT

Test instruments and reference standards needed for the trouble shooting analysis should have the following characteristics:

Parameter	Range	Accuracy	Measure/Generate* M/G
DC Voltage	−10-V to +10V 0 to +20V	±.01% ±5%	G M
AC Voltage	1kHZ 100mV	±0.1%	M/G
Timing Waveforms	Oscilloscope 5MHz BW	±5%	M

*Measure = indicates test instrument. Generate = indicates source instrument.

5.7 POWER SUPPLY TEST (Figure 5-4)

a. Select kΩ Function and 10MΩ Range.

b. Check dc voltages at points and in sequence shown in the tabular presentation below. Measurements should be made between the indicated point and ground reference. The latter is easily available at the metal

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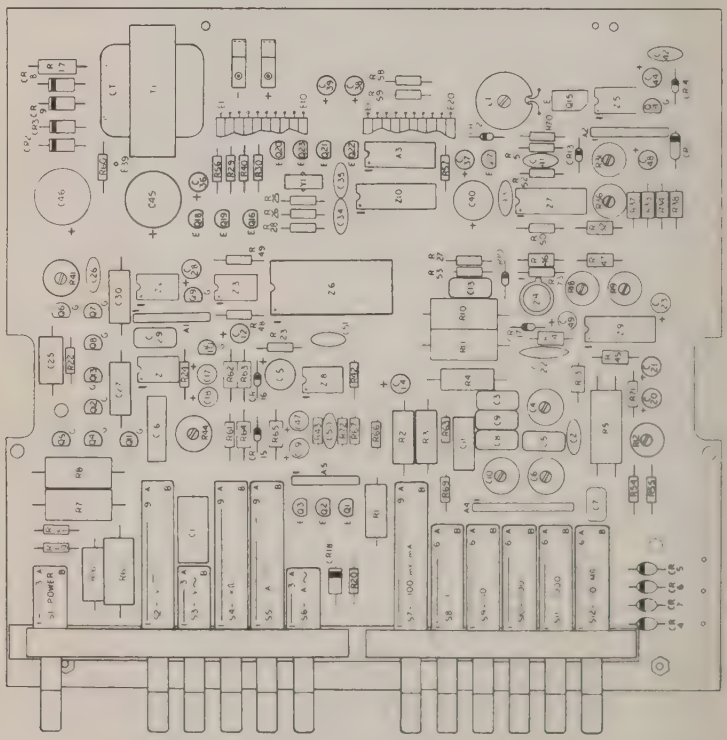

Fig. 5-3 Model 2480/2480R Main PC-Board

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support post for the analog shield as shown in Figure 3-1. See Figure 5-2 for designated test point location.

Test Point	Measure Value	Indicated Proper-Functioning Circuit
CR14-Cathode	+7.2V to +7.5V	DC/DC Converter Reference Zener
Battery-Negative	−7.0V to −6.6V	Negative Supply Regulator

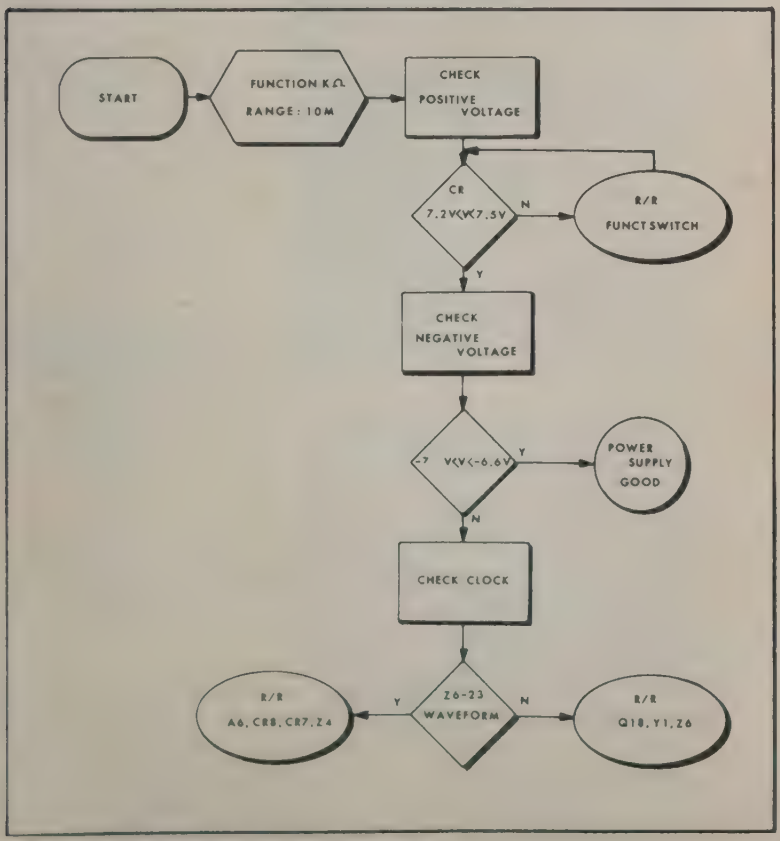

Fig 5-4 Power Supply Trouble Shooting

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c. Ground the positive battery electrode by momentarily connecting a jumper from that electrode to LO input. Check to see that the display presents the blinking decimal point of a low battery condition while the battery is thus shorted. If satisfactory performance is observed the Z3 circuitry is functioning properly.

d. Check waveform at Z6 pin 23. Proper functioning of master oscillator circuit (Y1) and count-down section of Z6 are indicated by observing a 100kHz square wave at amplitude of 4V p-p.

e. Check switching components of Z7 and Q17 for waveforms as shown below. (See Reference Fold Out for circuit schematic.)

5.8 DIGITAL LOGIC TEST

All the digital logic functions are essentially implemented in two CMOS chips, Z6 and Z10. The separate and sometimes independent function performed by these LSI circuits are checked as shown in Figure 5-5. Proceed as shown below. (A simplified block diagram of Z-6 was shown in Figure 4-6.)

5.8.1 Time-Base Generation

Check 100kHz Clock. Waveform at Z6-23 should have 6.8V p-p amplitude. If not, trace from origin at master timing oscillator and Z6.

5.8.2 Program Logic

a. Jumper Z6-10 to Z6-9. This connects comparator output to P3·(–). At end of Phase 2, the meter then sees an apparent negative input to the meter, and causes P3·(–) to go high (to apply a positive reference to the A/D buffer input). But this also appears as a change in comparator output (signifying a zero crossing of the integrator during Phase 3), and the A/D immediately recycles to auto-zero (Phase 1) for the 300 msec.

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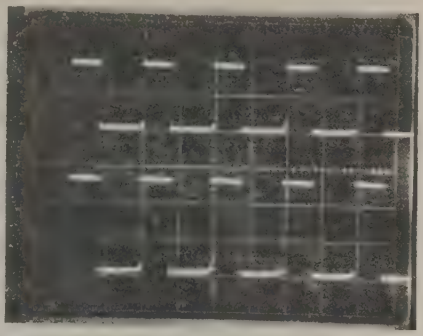
Q17 COLLECTOR
Low Line Low Battery

Q17 COLLECTOR
High Line, High Battery

10V/DIV : 5uSEC/DIV

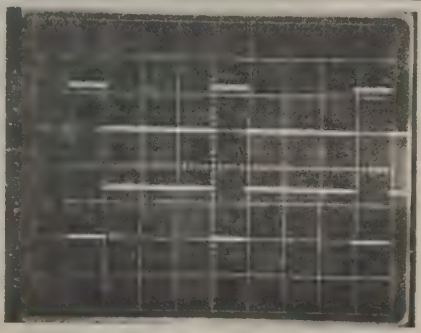


Z10-9 JUMPERED
TO Z10-10

P2(PHASE 2)

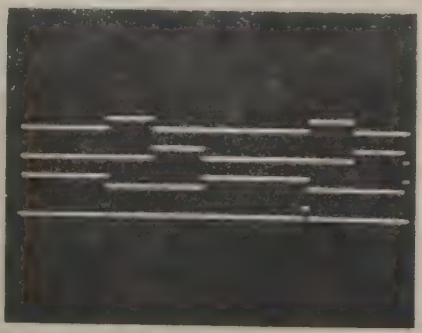
P1 (PHASE 1)

(P3 = Low, FC = Low)
5V/DIV; 100 mSEC/DIV



INPUT
OVERLOAD POSITIVE

P1
P2
P3(+)
FC



LOGIC ANALYZER

Fig. 5-6 Digital Logic Waveforms (SCOPE)

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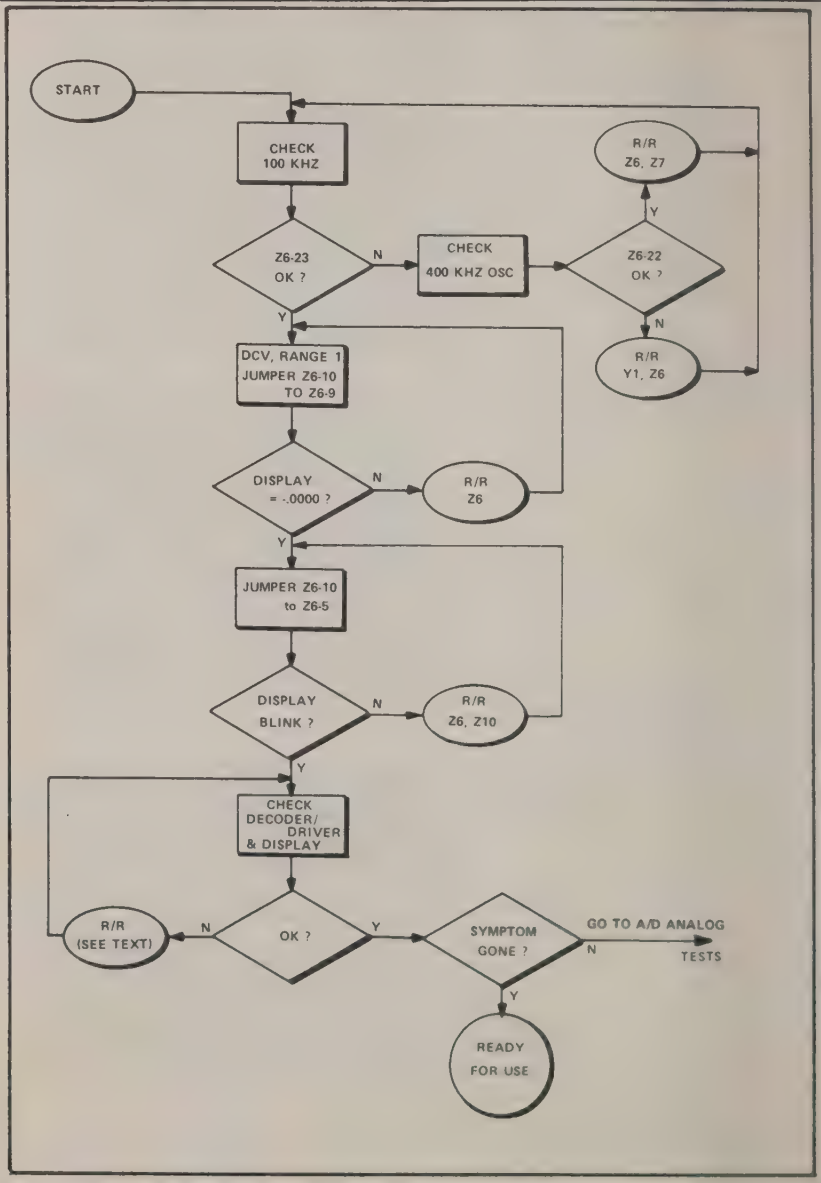

5-10 **Fig 5-5 Digital Logic Tests**

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b. Check display for – .0000. If incorrect, check waveforms at phase control signal outputs of Z6. If the timing signals are correct (and display is not), then check Z6 and its circuit components.

c. Jumper Z6-10 toZ6-5. This connects comparator output to – 6.8V. Since this does not change, the meter appears to see an out-of-range condition for every other cycle. This causes alternate blanking of the digits, and indicates proper operation of the out-of-range logic timing circuit in Z6.

5.8.3 Decoder/Driver Logic

a. Check display as range scale is changed. Observe response of decimal point. Check decimal point switch, current limiting resistor, or display digit for any noted malfunction.

b. If any digit is totally "out", check current switching transistor for that digit. (See reference schematic fold out.)

c. If any segment is "out" in all digits, check decoder driver Z10.

d. If polarity sign or MSD "1" is out, check Z6, the appropriate current switching transistor, or the display digit.

5.9 A/D CONVERTER & SIGNAL CONDITIONERS TEST (Fig 5-7)

5.9.1 Analog A/D

a. Select DCV measuring function

b. Connect Z6-10 to Z6-9 and synchronize oscilloscope to positive going edge of P2 waveform by connecting to Z6-15. Observe waveform development as shown in Figure 5-8 & following sequence shown in Figure 5-7.

4.9.2 AC/DC Converter

a. Select ACV function. 100mV Range.

b. Apply 100mVRMS @ 1kHz to HI and LO.

c. Observe waveform at output of Z4-6 by placing scope at junction of R12 and Z4-6 pin. Performance of Z4 is satisfactory when output waveform is 10 times input.

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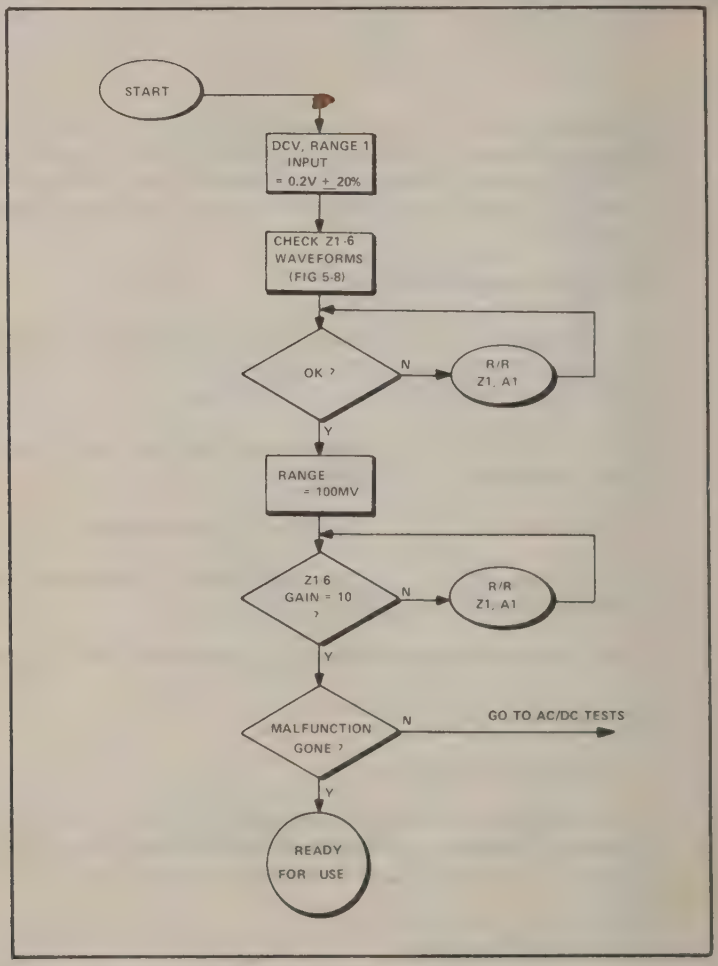

Fig 5-7 A/D Analog Signal Conditioning

d. Check operation of AC DC rms converter by observing output of Z8 for Model 2480; Z9 for Model 2480R. DC voltage should be 1 volt for 1VAC output of Z4-6. Check waveform shape to see that it is pure sinusoid. Output of ac/dc converter may be checked at switch S5 contact B4. (Figure 5-2).

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INPUT = +200mVDC;
RANGE = 100mV

Z2-6

Z1-6

2V/DIV; 100mSEC/DIV

INPUT = +200mVDC;
RANGE = 1V

Z2-6

Z1-6

2V/DIV; 100mSEC/DIV

INPUT = 100mV @ 1KHz

Z4-6

Z8-6

2V/DIV; 1 mSEC/DIV

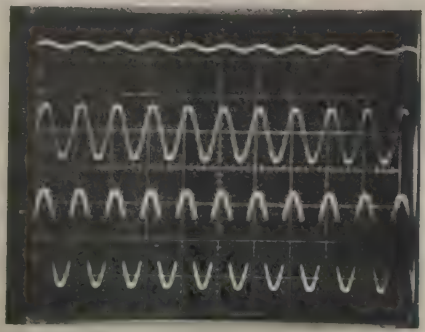

Fig. 5-8 A/D Waveforms (SCOPE)

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5.9.3 Kilohms Signal Conditioning (Figure 5-9)

a. Select KΩ measuring mode, and range 1KΩ.

b. Use high impedance test voltmeter to measure voltage at input terminals. Properly operating current-limited voltage source will develop about 1.5 to 2 volts.

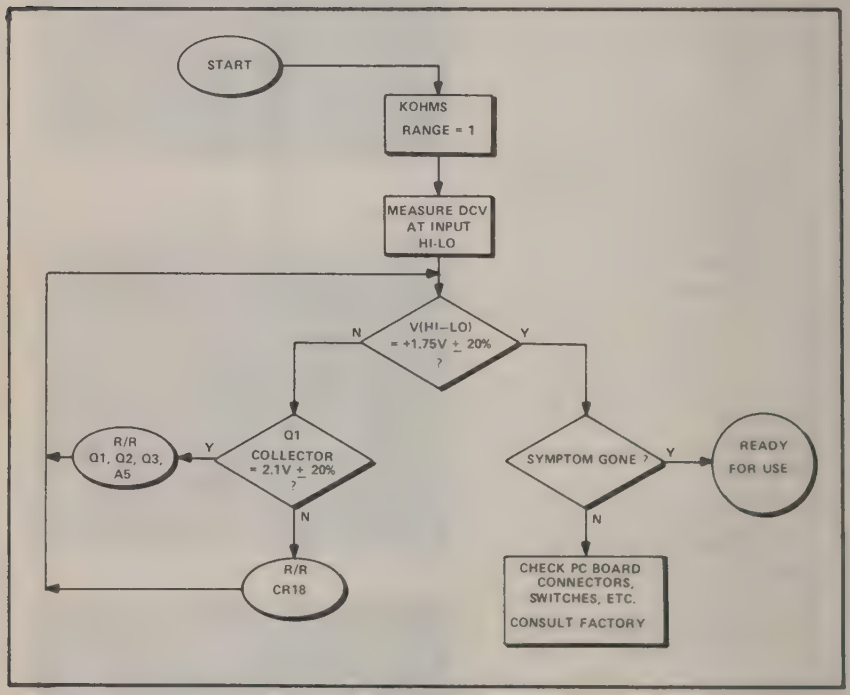

Fig 5-9 KΩ Signal Conditioning Tests

5.10 POST TROUBLE-SHOOTING & REPAIR

(a) Disconnect all power.
(b) Replace analog shield; refasten display flex to front panel assembly; replace top cover.
(c) Reconnect power.
(d) Allow DMM to warm up for ½ hour.
(e) Recalibrate as in Chapter 3.

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Chapter 6
PARTS LIST

6.1 MAIN PC-BOARD (LESS AC/DC CONVERTER)

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER
A1	RESISTOR NETWORK	22-48-1062
A2	RESISTOR NETWORK	22-48-1063
A3	RESISTOR NETWORK, 300Ω, DIP 14/7	22-701007
A4	INPUT ATTENUATOR NETWORK	22-48-1085-02
A5	RESISTOR NETWORK	22-68-1014
C1	CAPACITOR, 0.022μf, 1000V, 10%	23-210307
C2	13 pf, 5%	23-711003
C4,6,10	5.5-65 pf, TRIM, TOP ADJ.	23-810020
C5	39 pf, 5%, 500V, DM15	23-311013
C3	20 pf, 5%, DM10	23-310003
C8	1000 pf, 5%, 100V, DM10	23-311002
C11	0.01μf, 50V, 2%, PSTY	23-510024
C29	10 pf, 5%, DM10, MICA	23-310002
C12,28,36,37,38		
C39,44,48,49	15μf, 10V, 20% TANT	23-441003
C25	0.056μf, 50V MIN, 10%	23-510020
C26	5 pf, 10%, 1KV, CERM	23-111000
C27	0.47μf, 10%, 50V, PC	23-510018
C22	150 pf, 500V, DM15, MICA	23-311015
C30	1μf, 50V, 10% (SELECTED)	23-510001-A
C34,43	39 pf, 10%, 1KV, CERM	23-110014
C35,42	68 pf, 10% 1KV, CERM	23-110019
C7	3 pf, 500V, DM10, MICA	23-310008
C40	CAPACITOR, 100μf, 35V, AL EL	23-620002
C41	CAPACITOR, 0.01μf, 150V, CERM	23-111006
C45,46	CAPACITOR, 1000μf, 16V, AL EL	23-620001
CR1	DIODE, REF	24-48-1001
CR2,3	IN4733A, 5.6V, ZENER	24-121001
CR5,6	A14U, RECTIFIER	24-102001
CR8,9	IN4004, RECTIFIER	24-104004
CR10,12,13,14,17	IN4148, SILICON	24-110001
CR18	DIODE, IN4007, RECTIFIER	24-104007
CR4,7	DIODE, A14U, SELECTED	24-48-1154
L1	INDUCTOR, 7.0μH	25-48-1083
Q1,2,3	TRANSISTOR, MPSA92, PNP	24-240A92
Q4 THRU Q10	TRANSISTOR, FET, N-CHANNEL, BLU	24-48-1014-02

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Q11,12	**TRANSISTOR, FET, N-CHANNEL, GRN**	24-48-1014-03
Q13	FET, P-CHANNEL	24-210177
Q14	J-FET, U1897E, N-CHAN	24-211897
Q15	D40D2	24-2240D2
Q16,19	MPS6519	24-246519
Q17,18,20,21,22,23	TRANSISTOR, GES5818, TO-92 STD	24-235818-A
R1	RESISTOR, 900Ω, ±.07%	22-68-1015-01
R2	90Ω, ±.07%	22-68-1015-02
R3	9Ω, ±.07%	22-68-1015-03
R4	0.9Ω, ±.15%	22-68-1015-04
R5	0.1Ω, ±.15% (4 LEAD)	22-68-1015-06
R6,7,8	51K, 2W, 5%, C.C.	22-055139
R10,11	330K, 2W, 5%, C.C.	22-053349-A
R12	RESISTOR, 50Ω, TRIM, TOP ADJ.	22-673500
R16	RESISTOR, 150K, 5%, 1 W, C.	22-041549
R17	RESISTOR, 22Ω, ½ W, C.	22-032209
R13,14	RESISTOR SET 8975Ω (R13) 1000Ω (R14)	22-48-1069-2
R31,36	RESISTOR, 200Ω, TRIM, TOP ADJ.	22-673201
R33,34,38	RESISTOR SET 52K (R33) 9K (R34) 1028Ω (R38)	22-48-1069-1
R37	**RESISTOR, 39.2K, 1%, RN55C**	**22-343922**
R41	100K, TRIM, TOP ADJ.	22-673104
R27	1K, ¼W, 5%, C	22-021029
R53	5.1K, ¼W, 5%, C	22-025129
R22	16K, ¼W, 5%, C	22-021639
R23	RESISTOR, 33K, ¼W, 5%, C.	22-023339
R24	RESISTOR, 68K, ¼W, 5%, C.	22-026839
R20,70	1 6K, ¼W, 5%, C	22-021629
R21	FSV (22M), ¼W, 5%, C	22-022269
R51,54,55	RESISTOR, 100K, ¼W, 5%, C	22-021049
R60,73	RESISTOR, 10Ω, ¼W, 5%, C.	22-021009
R25,71	7 5K	22-027529
R26	2 2M	22-022259
R28	10K	22-021039
R19,29,30	750Ω	22-027519
R40	1 2K	22-021229
R56,57,58,59	510Ω	22-025119
R48,49,50	27K	22-022739
R52	RESISTOR, 3.3K, ¼W, 5%,C.	22-023329
R74	**RESISTOR, 360M, ½W, 20% (FSV OPT'L)**	22-033677
S1 Thru S6	SWITCH, MODE	C68-1043
S7 Thru S12	SWITCH, RANGE	C68-1042
T1	TRANSFORMER, 115V LINE (STD)	C68-1012-02
T1	TRANSFORMER, 100V LINE ("J")	C68-1012-01
T1	TRANSFORMER, 230V LINE ("E")	C68-1012-03

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Y1	RESONATOR, 400K Hz	25-141000
Z1	I.C., LF356, SELECTED, BLUE DOT	**24-68-1033**
Z2	I.C., OP AMP, LF351	24-400351
Z3	I.C., DUAL COMP, LM393	24-400393
Z4	I.C., LF356, SELECTED YEL DOT	**24-48-1118**
Z5	I.C., DUAL OP. AMP, TL062	24-400062
Z6	I.C., LSI CMOS A/D LOGIC	24-48-1058
Z7	I.C., CMOS, NAND GATE, 74C00	24-G74C00
Z10	I.C., DECODER/DRIVER	24-L14511

6.1.2 MODEL 2480 AC/DC

C14	CAPACITOR, 1μf, 35V, 20%, TANT	23-441001
C15	33μf, 10V, 10%, TANT	23-441004
C17,18,47	6.8μf, 20V, 20%, TANT	23-441005
C16	0.33μf, 100V, 10%	23-211001
C19	CAPACITOR, 3.3μf, 16V, 20% TANT	23-441007
C50	CAPACITOR, 39 pf, CERMDISC	23-110014
C51	CAPACITOR, .1μf, 12V	23-118206
CR15,16	DIODE, SCHOTTKY, 5082-2800	24-110004
R66	RESISTOR, 100K, ¼W, 5%, C	22-021049
R42	33K, ¼W, 5%, C	22-023339
R61	430K, ¼W, 5%, C	22-024349
R43	66.5K, 1%, RN55D	22-336652
R62	34K, 1%, RN55C	22-343402
R63	10K, 1%, RN55C	22-341002
R44	RESISTOR, TRIM, 5K, TOP ADJ.	22-673502
R64	RESISTOR, 10K	22-68-1021-01
R65	RESISTOR, 5.62K	22-68-1021-02
R67	RESISTOR, 330K, ¼W, 5%, C	22-023349
R72	RESISTOR, 4.7K, ¼W, 5%, C	22-024729
Z8	I.C., OP. AMP., 318	24-400318

6.1.3 MODEL 2480R AC/DC

C20	CAPACITOR, 4.7μf, 35V, 20%, TANT	23-441052
C21	CAPACITOR, 3.3μf, 16V, 20%, TANT	23-441007
C13	CAPACITOR, 270 pf, 500V, Dm15, MICA	23-311022
C23	CAPACITOR, 1μf, 35V, 20%, TANT	23-441001
R9	RESISTOR, TRIM, TOP ADJ., 100K	22-673104
R18	RESISTOR, TRIM, TOP ADJ., 500Ω	22-673501
R45	RESISTOR, 205Ω, 1%, RN55C	22-342050
R46	RESISTOR, 49.9Ω, 1%, RN55C	22-3449R9
R47	RESISTOR, 100K, 1%, RN55C	22-341003
Z9	I.C., RMS TO DC CONVERTER, 3737	24-423737

6.2 DISPLAY CARD ASSEMBLY

DS100	DISPLAY OVERFLOW	25-227656
DS101-DS104	DISPLAY 7 SEGMENT	25-227653

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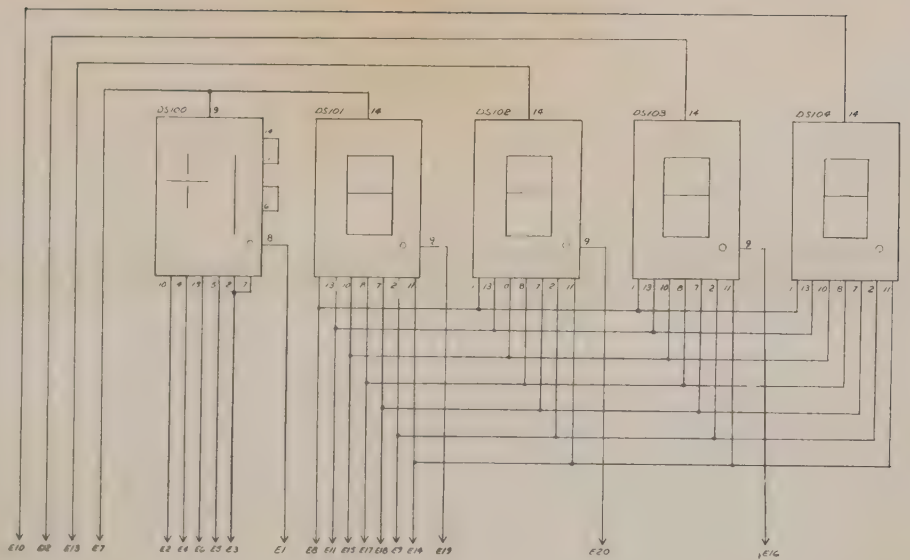

REQD	ITEM	PART NO	CIRCUIT SYM	DESCRIPTION	MATL SPEC

LIST OF MATERIAL

DATA PRECISION

SCHEMATIC
DISPLAY CARD

51682 D 65-1020 M

SHEET 2 OF 2

NEXT ASSY | USED ON

APPLICATION

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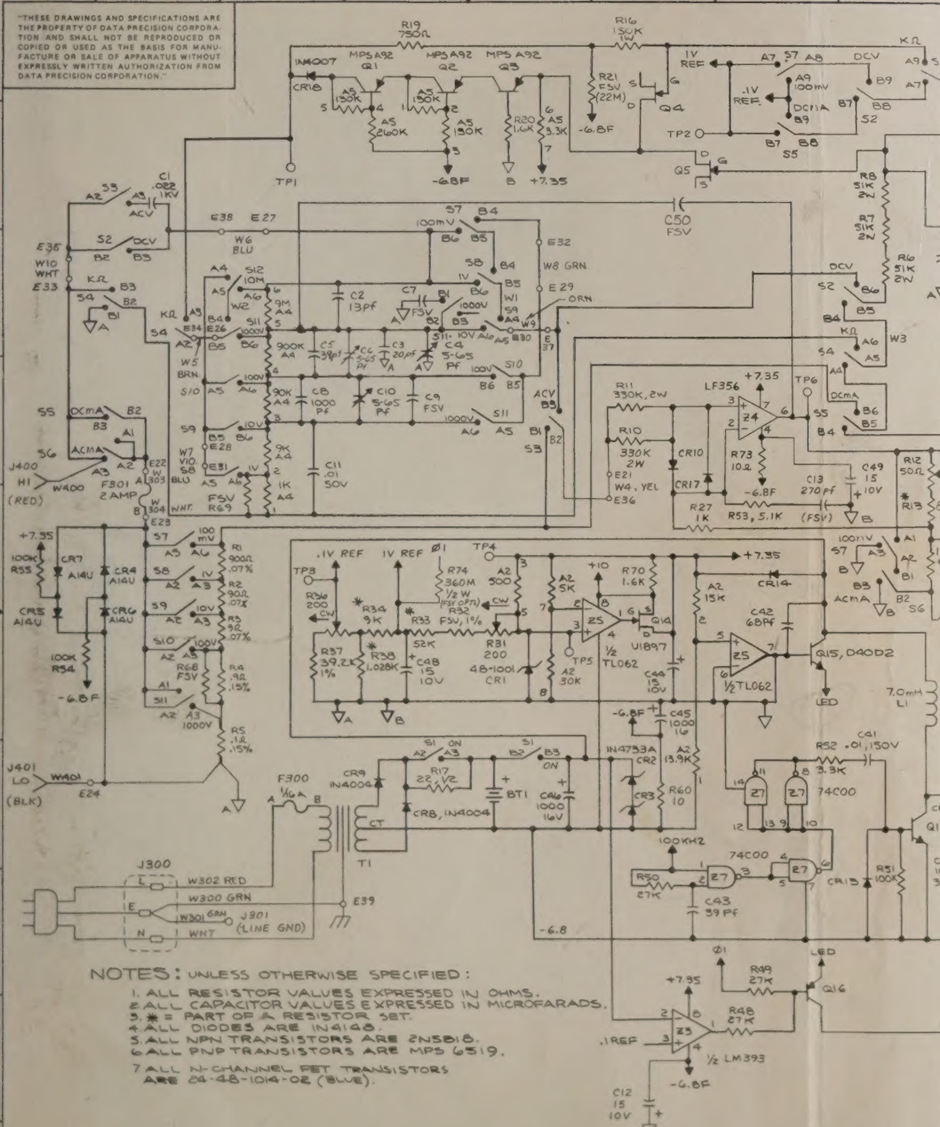
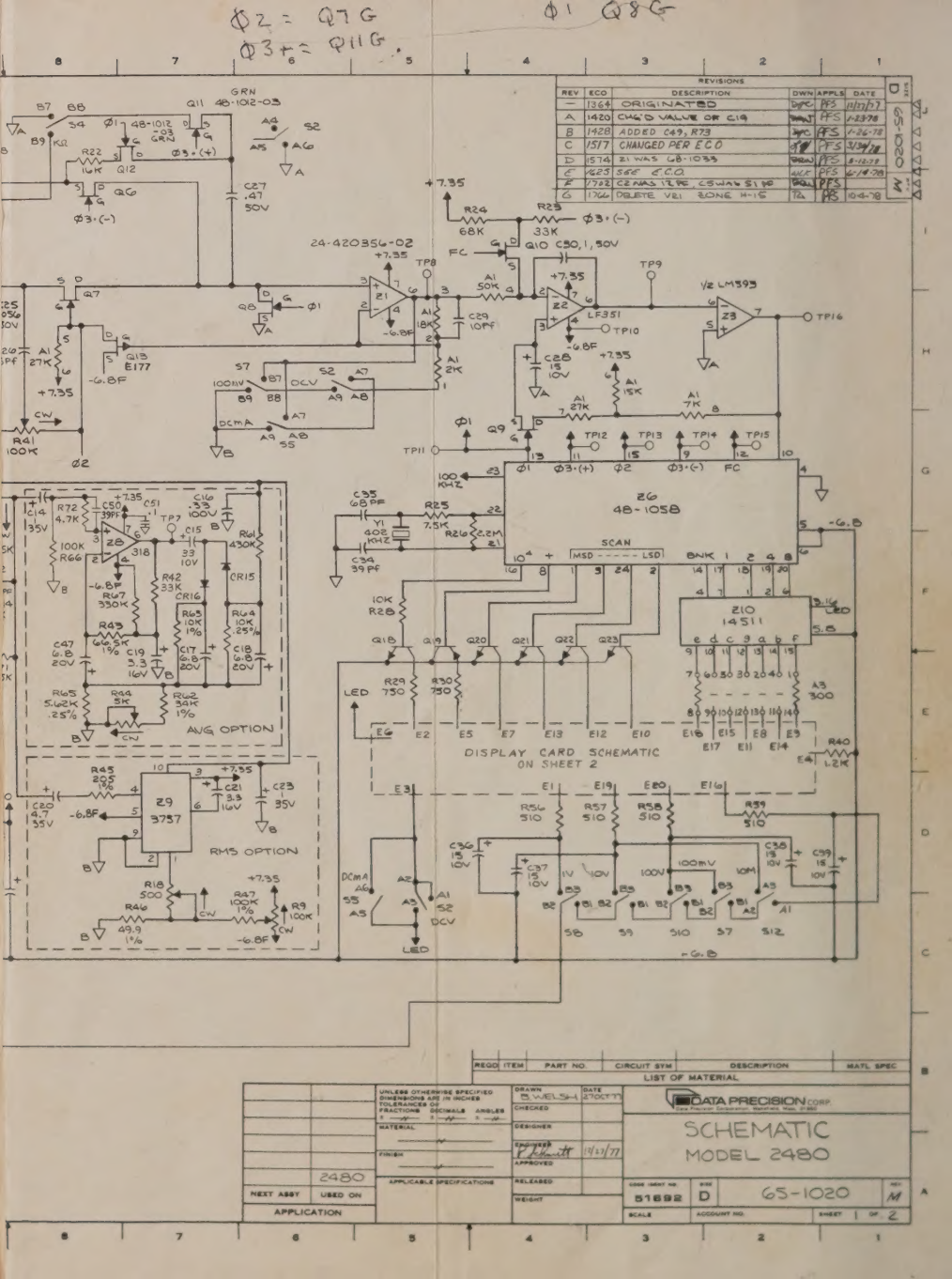
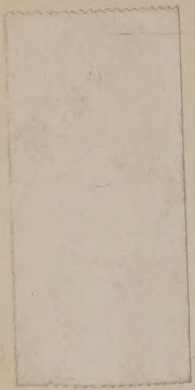

R19 750Ω
1N4007 CR18
MPS A92 Q1
MPS A92 Q2
MPS A92 Q3
A5 130K
A5 260K
A5 130K
R20 1.6K
A5 3.3K
TP1
-6.8F
+7.35
R16 150K 1W
R21 FSV (22M)
Q4
Q5
1V REF
.1V REF.
TP2
S7
DCV
A9 100mV
DCmA
S2
S5
KΩ
R8 51K 2W
R7 51K 2W
R6 51K 2W
C1 .022 1KV
S3
ACV
E38
E27
W6 BLU
E35
W10 WHT
E33
S4
C50 FSV
E32
W8 GRN.
E 29
ORN
S12 10M
W2
9M A4
C2 13pf
C7
FSV
1000V
W1
W9
S11
E34
E26
E30
E37
W5 BRN.
900K A4
C5 39pf
C6 5-65 Pf
C3 20pf
C4 5-65 Pf
S10
100V
90K A4
C8 1000 Pf
C10 5-65 Pf
C9 FSV
S9
10V
9K A4
1K A4
E28
W7 VIO.
S8
E31
FSV R69
C11 .01 50V
W3
R11 330K, 2W
R10 330K 2W
E21
W4, YEL
E36
CR10
CR17
LF356
Z4
TP6
R73 10Ω
C13 270pf
C49 15 10V
R27 1K
R53, 5.1K
(FSV)
R12 50Ω
R13
S5
S6
DCmA
ACmA
J400 HI (RED)
W400
F301 2 AMP
W 303 BLU
W 304 WHT.
E22
E23
+7.35
100K R55
CR7 A14U
CR4 A14U
CR5 A14U
CR6 A14U
100K R54
-6.8F
S7 100 mV
R1 900Ω .07%
S8 1V
R2 90Ω .07%
S9 10V
R3 9Ω .07%
S10 100V
R68 FSV
R4 .9Ω .15%
S11
1000V
R5 .1Ω .15%
J401 LO (BLK)
W401
E24
.1V REF
1V REF
Ø1
TP4
TP3
R36 200
CW
R34 9K
R33
R74 360M 1/2 W (FSV OPT'L)
R32 FSV, 1%
A2 500
R37 39.2K 1%
R38 1.028K
52K
C48 15 10V
R31 200
48-1001 CR1
A2 5K
A2 30K
+10
R70 1.6K
Z5
1/2 TL062
Q14
U1897
TP5
C44 15 10V
+7.35
CR14
A2 15K
C42 68PF
Z5
1/2 TL062
Q15, D40D2
LED
7.0mH L1
S1 ON
R17 22, 1/2
S1 ON
BT1
C46 1000 16V
CR9 1N4004
CR8, 1N4004
F300 1/16 A
T1
CT
1N4733A CR2
CR3
-6.8F
C45 1000 16
A2 13.9K
R60 10
R52 3.3K
C41 .01, 150V
Z7
74C00
100KHZ
R50 27K
C43 39 PF
CR15
R51 100K
Q16
-6.8
J300
W302 RED
W300 GRN
W301 GRN
J301 (LINE GND)
WHT
E39
R49 27K
R48 27K
+7.35
.1REF
Z3
1/2 LM393
-6.8F
C12 15 10V

NOTES: UNLESS OTHERWISE SPECIFIED:

1. ALL RESISTOR VALUES EXPRESSED IN OHMS.
2. ALL CAPACITOR VALUES EXPRESSED IN MICROFARADS.
3. * = PART OF A RESISTOR SET.
4. ALL DIODES ARE IN4148.
5. ALL NPN TRANSISTORS ARE 2N5818.
6. ALL PNP TRANSISTORS ARE MPS 6519.
7. ALL N-CHANNEL FET TRANSISTORS ARE 24-48-1014-02 (BLUE).


Φ2 = Q7G
Φ3+ = Q11G.
Φ1 Q8G
REVISIONS
REV | ECO | DESCRIPTION | DWN | APPLS | DATE
- | 1364 | ORIGINATED | DPC | PFS | 11/17/77
A | 1420 | CHG'D VALUE OF C19 | DPC | PFS | 1-23-78
B | 1428 | ADDED C49, R73 | DPC | PFS | 1-26-78
C | 1517 | CHANGED PER ECO | DPC | PFS | 3/24/78
D | 1574 | Z1 WAS 48-1033 | DPC | PFS | 5-12-78
E | 1625 | S&E ECO | DPC | PFS | 6-14-78
F | 1722 | CHNG'S TYPE, CSWAY S1,S2 | DPC | PFS | 9-8-78
G | 1746 | DELETE V.I. ZONE H-15 | DPC | PFS | 10-6-78
65-1020 M
24-420356-02
+7.35
-6.8F
Z1
Z2
Z3
1/2 LM393
LF351
Z6
48-1058
SCAN
MSD ----- LSD
BNK 1 2 4 8
Z10
14511
Z9
3737
AVG OPTION
RMS OPTION
DISPLAY CARD SCHEMATIC
ON SHEET 2
100 KHZ
402 KHZ
100mV
1V
10V
100V
DCMA
DCV
LED
TP7
TP8
TP9
TP10
TP11
TP12
TP13
TP14
TP15
TP16
REQD ITEM | PART NO. | CIRCUIT SYM | DESCRIPTION | MATL SPEC
LIST OF MATERIAL
DATA PRECISION CORP.
SCHEMATIC
MODEL 2480
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES OF FRACTIONS DECIMALS ANGLES
MATERIAL
FINISH
APPLICABLE SPECIFICATIONS
DRAWN B. WELSH 2/10/77
CHECKED
DESIGNER
APPROVED P. Schmidt 12/27/77
RELEASED
WEIGHT
SCALE
ACCOUNT NO.
SHEET 1 OF 2
CODE IDENT NO. 51692
SIZE D
65-1020
REV M
NEXT ASSY 2480
USED ON
APPLICATION



62-5010-E

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